A CHARACTERISATION OF TASMANIAN WOOL QUALITY AND THAT OF SIMILAR WOOL PRODUCING REGIONS ON THE AUSTRALIAN MAINLAND FOR THE 1991/92 TO 1996/97 SEASONS

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DECLARATION

I declare that this thesis contains no material which has been accepted for the award of any other degree or diploma in any tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

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ABSTRACT

Tasmania produces a small proportion, between 2-3% of Australia's wool. The wool produced has the reputation worldwide of producing a high quality fine product. There is however no supporting evidence or general characterisation of Tasmanian wool quality. It is thought that if the superiority of Tasmanian wool could be demonstrated that it could be used to optimise and develop markets for Tasmanian wool. The Tasmanian wool clip is not uniform but rather a highly variable product and this is expressed by the region of production, sheep breed and type, farming system, seasonal conditions and flock management. The interactions of these factors have resulted in considerable variation in the productivity of sheep between different regions.

The characteristics of Tasmanian wool have been analysed using wool test results across the season's 1991/92 to 1996/97. The Tasmanian areas analysed incorporated the East Coast, Midlands and Flinders Island. The results of this characterisation showed that Tasmania's wool quality varies considerably between seasons and across the state. It also determined that:

1. Tasmania had high levels of staple strength faults across the state.
2. Colour fault levels were low except for the northern part of the state where the annual rainfall is high and influences the clean colour of the fleece.
3. Vegetable matter fault was at very low levels across the state and rarely reached above the 1.1% level in the fleece wool. The only significant type of vegetable matter present was seed/shive. Burrs and hardheads occurred at minuscule levels.

Key competing areas, with Tasmania, in NSW and Victoria were selected and also characterised so to determine the advantages or benefits of Tasmanian wool. This characterisation also showed the high levels of variation between states and seasons. Upon comparing the levels and variation of the various faults across the three states, it indicated:

a) Tasmania had the lowest levels of vegetable matter fault across the three states.

b) Colour levels within the fleeces were influenced by the climatic conditions of the season and followed a seasonal pattern across the six seasons (1991/92 to 1996/97) within all states. Tasmania had the lowest levels of colour fault excluding the northern area of the state.

c) Staple strength is the area of wool quality that is Tasmania's downfall when comparisons are made with NSW and Victoria. Tasmania has a higher occurrence of strength faults across the state than either NSW or Victorian areas.

Although strength faults have been reduced within Tasmania across the six seasons it is still not uncommon for over 20% of fleeces to have a strength fault within any one season. However a number of areas within Tasmania have managed to reduce the occurrence of staple strength faults over the last six seasons.

The key to improving strength across the state is to determine the combination of management practices that are producing sound wool. Identifying the growers that are producing sound wool and determining the methods with which they are reducing the occurrence of faults and variation within their clip may do this. The different management practices may also be looked at between the states to determine why NSW and Victorian areas have a lower occurrence of strength faults.

Once the key issues have been identified the knowledge must be transferred to all wool producers so as to reduce the amount of strength faults within Tasmanian wool. Therefore, allowing Tasmania to produce sound wool and uphold and maintain their world reputation for producing the best quality Merino wool in the world.

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Chapter One: Introduction

Hypothesis

Reduced between season, climatic/regional/pastoral variation leads to increased consistency of product quality for Tasmanian wools compared to Australian mainland competitors.

Tasmania produces only a small proportion, approximately 2-3%, of Australia's wool. Tasmanian wool has developed a reputation worldwide of being a high quality product mostly in the fine and superfine micron categories. When examined closely, it is clear that the Tasmanian wool clip is not uniform but highly variable. This variability arises due to factors such as production region, sheep breed and type, farming system, seasonal conditions and flock management. The interactions of these factors have resulted in considerable variation in the productivity and wool quality characteristics of sheep between different regions within Tasmania and throughout Australia.

The similarities between wool produced in different geographical areas and across seasons can be determined by analysing wool quality data. Fibre diameter, yield, style, strength, colour, length and vegetable matter content combine to determine what is loosely referred to as 'wool quality'. These properties are of importance as they combine to determine how wool will perform during processing.

Two analyses were conducted to determine the variability of wool production and quality throughout Tasmania and to compare Tasmania to other regions on mainland Australia. Consultation with Tasmanian wool brokers identified areas within Australia that were considered to produce similar wool to Tasmania and therefore compete with the Tasmanian wool market. The areas identified were the higher rainfall, improved pastures of the tableland areas of New South Wales (NSW) and the western district of Victoria.

In the first analysis the wool quality of Wool Statistical Areas (WSA) within Tasmania were analysed and compared over the six wool growing seasons from 1991/92 to 1996/97.

The second analysis involved selecting key WSA in these regions, and comparing their wool quality to that of Tasmanian WSA over the same six seasons. These analyses were conducted to determine geographical differences for wool production between and within states, as well as to identify any differences in wool quality, which may exist between regions.

In a third analysis wool originating from Tasmania, NSW and Victoria was compared to determine if the influences of wool characteristics on price varied between regions. The effect of each characteristic on clean price was determined. Differences in price penalties or premiums between states were analysed across the six seasons.

A profile of Tasmania's wool clip and that from the main competing regions in NSW and Victoria has been determined, as well as the affects of wool characteristics on price and variation in price discounts between states. It is envisaged that Tasmania's wool industry will be able to utilise this information to optimise and develop their markets through improving wool quality, thereby maintaining their image as a producer of high quality Merino wool.

Chapter Two: Literature Review

2.1 Introduction

The Tasmanian wool industry has been worth approximately $80 million at the farm gate for the seasons, 1991/92 to 1996/97. To hold and increase this market share the wool industry must improve fibre quality through better understanding and managing of the quality variability inherent in a natural fibre. Wool quality varies due to environmental and physiological factors such as nutrition, season and genetics and hence will differ within and between geographical or statistical regions.

This chapter will review climate, geography and history of wool production in Tasmania, as well as the environmental and physiological influences on wool production and quality.

2.2 Tasmanian Geography and Climate

Tasmania is an island of 67,897 sq. km, latitude 40-44° S. Physically it is part of the Eastern Australian Highlands and this is reflected in the north-south direction of the major mountain ranges. It has a temperate marine climate, which is due broadly to the heat absorption and storage by the seas, which produces abnormally mild winters and cool summers for the latitude (Langford, 1965). Wool production within Tasmania is focused around the central highlands or midland areas and the east coast of the state.

2.2.1 Temperature

Tasmania has a temperate climate. Throughout the coastal districts the winter months produce mean temperatures below 10° C. In the inland districts such as Oatlands and Campbell Town six months of the year are cooler than 10° C and if the elevation is greater than 900 metres above sea level, for example Ouse, the period extends to eight months.

In mid-summer the inland districts of the state are warmest, a mean maximum of 24°C being characteristic of the central Derwent valley and the area from Launceston through Cressy almost to Ross. Means for elevations below 300 metres range between 24°C and 18°C, the latter being typical of the coastal west and south. In winter the dominance of outgoing radiation and the predominantly westerly flow shift the location of highest mean maxima to the extreme East Coast. The entire coastline is warmer than the adjacent hinterland in this season, reversing the situation which exists in mid-summer (Langford, 1965).

Highest annual temperatures occur in the east and south east of the state where all the country below 300 metres has experienced temperatures of at least 38°C. In the south-east such hot days occur as the last day of a warm spell during which a hot and dry air mass has been adverted from the Australian continent (Langford, 1965).

2.2.2 Rainfall

The majority of Tasmania has a winter-dominant rainfall pattern excluding the south-east corner of the state, which tends to have non-seasonal rainfall. The annual rainfall throughout the state is variable (Figure 2.1). Hobart, Oatlands and Swansea show a lower and more even distribution of rainfall throughout the year but distinct relatively dry and wet periods are noticeable, dry late summer and late winter, wet late autumn and late spring (Langford, 1965).

The annual average rainfall highlights the concentration of very heavy falls over the western highlands and to a lesser extent over the north-eastern highlands. In the coastal low country, heavy amounts are restricted to the north and west, while a distinct rainshadow is evident in central, eastern and south-eastern districts.

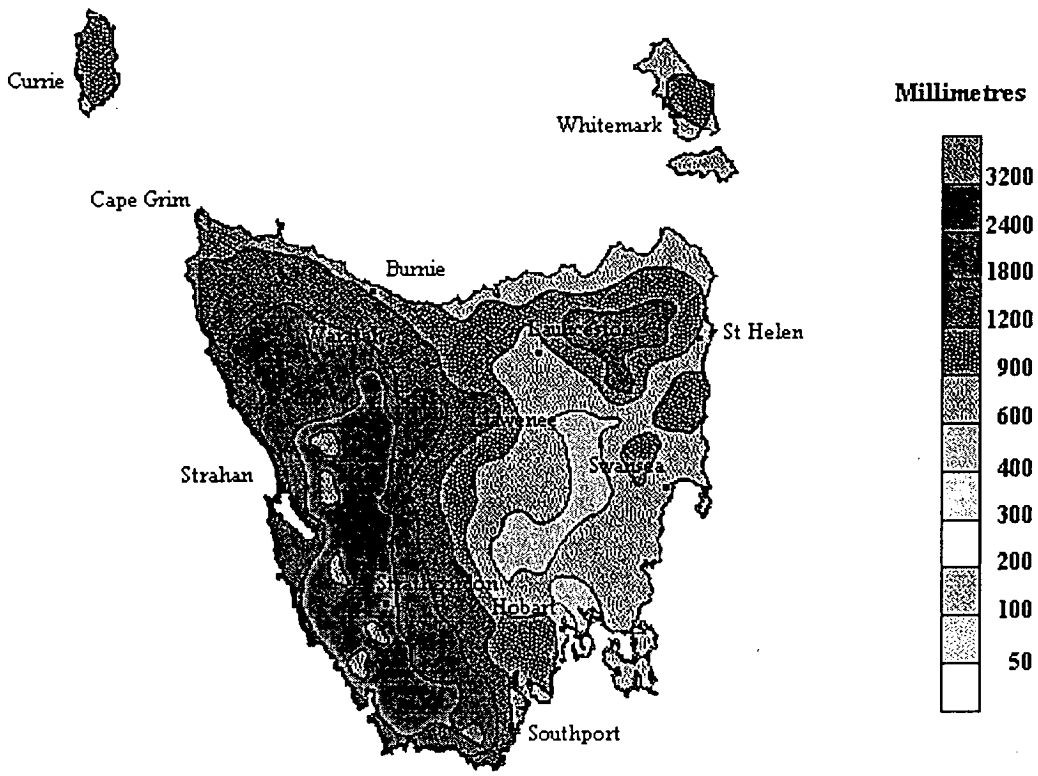


Figure 2.1: Annual Rainfall in Tasmania (mm)

2.2.3 Evaporation

Annual evaporation is uniform in the low level country of the north, east and south-east being between 790 mm and 865 mm. The higher values occur on the coast rather than inland and are typical of localities where high annual wind travel combines with ample sunshine. Amounts are much less in the west and south-west of the island, and, while 560 mm is the annual average at Roseberry, regions at high elevations would record less than 510 mm (Langford, 1965).

The effectiveness of monthly rainfall, that is its ability to compensate for evaporation, beginning germination and maintaining pasture growth above the wilting point, is adequate throughout Tasmania from May to October. In mid-summer months therė is about one chance in two of effective rainfall being received in the coastal country of the north and over less elevated country of the central and south-east districts (Langford, 1965).

2.3 History of Tasmanian Sheep and Wool

While the first merinos may have been introduced into Tasmania shortly after MacArthur imported them into New South Wales, there were certainly small introductions in 1809 and in 1816. Three hundred of MacArthur's stud lambs were imported in 1820 and distributed among the graziers, and a further flock of 100 Saxon merinos was secured in 1826. After 1820 wool production for the expanding Yorkshire textile industry rapidly became the dominant farming activity in Tasmania (Scott, 1965).

By 1831 there was a sizeable export trade from the island, with over two million pounds (800 tonnes) of wool being exported, together with very large shipments of wheat and other grains. Most of the best grazing land had been granted to free settlers with capital, so that in 1831, the free land grants were stopped.

The first Tasmanian wool sale by auction was held by A.G.Webster in December 1871 and by the turn of the century special wool sales for foreign buyers were inaugurated, materially benefiting the woolgrowers of Tasmania (Webster, 1988).

The most extraordinary aspect of the history of the grazing industry in Tasmania is the speed with which the flock was improved, both overall and in respect of the several breeds. It was Tasmanian sheep, which were largely responsible for the improvement of early flocks in Western Australia, South Australia and New South Wales (Scott, 1965).

Concurrently with rising prices in the early 1900's, Tasmania exported a growing volume of wool produce to Britain. In 1930's graziers continued to expand their flocks and in 1931 sheep numbers exceeded two million for the first time. The increased carrying capacity was made possible by the success of a campaign for pasture improvement launched by the reorganised Tasmanian Department of Agriculture in 1927.

The Second World War saw a decline in wool production. However, in early post-war years agricultural recovery was slow but the wool boom of 1951 provided the means for much needed farm investment. Subsequently the decade 1954 to 1964 was one of unparalleled expansion. Sheep numbers increased by more than 50% through the rapid improvement in pastures and the reduction in competing rabbit populations (Scott, 1965).

Over the last 25 years there has been a steady increase in the influence of merino bloodlines at the expense of sheep breeds traditionally used for broader wools and meat. Hence today, most wool producing flocks produce fine to medium wool and generally have merino, comeback or Polwarth influence in their flocks (Tasmanian Wool Industry Statement, 1999).

Today, Merinos and comebacks make up 75% of Tasmanian sheep flock, mostly run in the lower (<700mm) rainfall area. They are carried for fine and medium wool production, although a varying proportion of cull and cast for age ewes are mated to British breed rams for prime lamb production.

Crossbred ewes (usually a Border Leicester ram mated to a wool breed ewe) are run specifically for prime lamb production in the medium (700mm – 1000mm) rainfall areas. Poll Dorset, Suffolk, Texel and Southdown are the major breeds of terminal sire ram mated to these ewes (*pers com.* R.Wallace).

As a consequence the distribution of the mean fibre diameter for Tasmania indicates there is a steady increase in the proportion of superfine and fine wools at the expense of medium and broad wool (Figure 2.2).

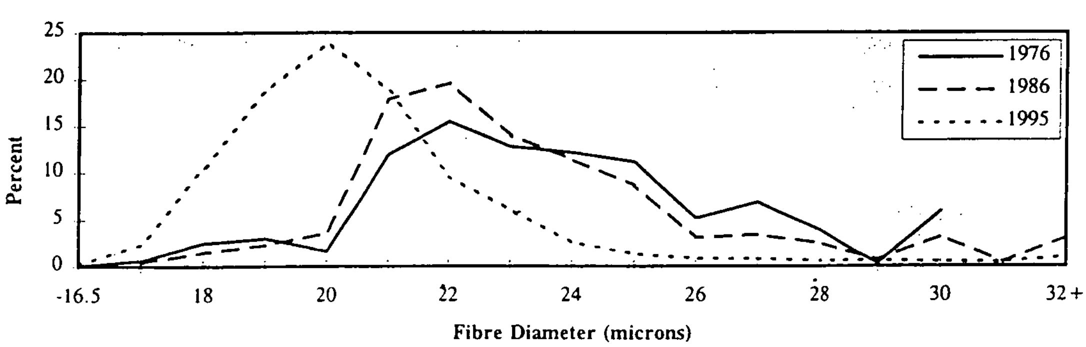


Figure 2.2: Mean Fibre Diameter for the Tasmanian Clip in 1976, 1986 and 1995 (DPIWE, 1998)

Wool production is susceptible to seasonal fluctuations and Tasmania has not been immune to this variability. Over the last ten years wool production in Tasmania has varied from 17.02 kilotonnes (kt) in 1995/96 to 25.45 kt in 1989/90. Prices received by growers have also been volatile (Table 2.1).

Table 2.1: Australian and Tasmanian Wool Production and Price (Webster/Roberts Annual Reports)

Year	Tasmanian Production (kt)	Average Australian Price (c/kg)	Australian Production (kt)	Tasmanian production as a % of Australian clip
1986/87	24.15	395.5	813.74	2.96
1987/88	21.15	632.7	843.05	2.51
1988/89	20.63	647.3	898.93	2.29
1989/90	25.45	555.3	1030.94	2.45
1990/91	21.97	413.8	989.18	2.22
1991/92	18.55	358.8	801.00	2.32
1992/93	18.12	313.5	815.05	2.22
1993/94	19.12	330.1	775.77	2.46
1994/95	18.27	503.3	682.50	2.68
1995/96	17.02	383.5	654.80	2.60
1996/97	19.74	369.4	653.40	3.02

The 1990/1991 year saw dramatic change in the wool industry. The wool season commenced with a reserve price of 700 cents/kg. Sales were suspended in February 1991 and resumed in March 1991 when the reserve price scheme was abandoned. During the year 10 million sheep were slaughtered in Australia under a flock reduction scheme designed to reduce wool production. The average price per bale fell from $1115 to $844 (Roberts, 1991).

Wool prices for 1992/93 were the lowest in real terms for at least 50 years, allowing for inflation. The industry had never been confronted with as many problems at the one time: volatility of exchange rates, poor economic conditions in many of the major importing countries of Australian wool, lack of consumer confidence, high stock levels of top and reluctance of processors to reward producers for high quality wool (Webster, 1993).

During the year the reduced clip caused Tasmania to fall short of the minimum bale offering required under Wool Selling Regulations, as a result the June 1993 sale was transferred to Melbourne. It was subsequently agreed that the October 1993 sale would also be transferred to Melbourne, with three designated Melbourne sales of Tasmanian wool in August, September and October 1993. Tasmania had for many years sold by separation in Melbourne, but the June 1993 sale was the first substantial catalogue of Tasmanian wools to be offered out of the state (Roberts, 1993).

In 1994/95 the state's sheep population and cut per head declined due to unfavourable seasonal conditions and low wool prices for the second successive year. Although the cut per head was down, the Tasmanian clip was finer than normal (Webster, 1994). It was also during this season that Tasmanian Quality Wool was established to draw all sectors and stakeholders of the Tasmanian wool industry together, to address quality management and other related issues.

In 1996/97 Tasmanian wool production increased marginally, however it still remained well below demand, with the national shortfall being met from sales of Wool International wool stocks. Therefore even though production was well below demand, stockpile sales depressed price.

2.4 Tasmanian Wool Statistical Areas (WSA)

Tasmania is divided into ten WSA (Figure 2.3). The WSA boundaries effective since July 1986, are based on the Australian Standard Geographical Classification introduced by the Australian Bureau of Statistics (ABS) for use with statistical collections, thus providing compatibility between ABS agricultural statistics and Wool International wool sale statistics. Wool production throughout the state can be allocated to specific WSA.

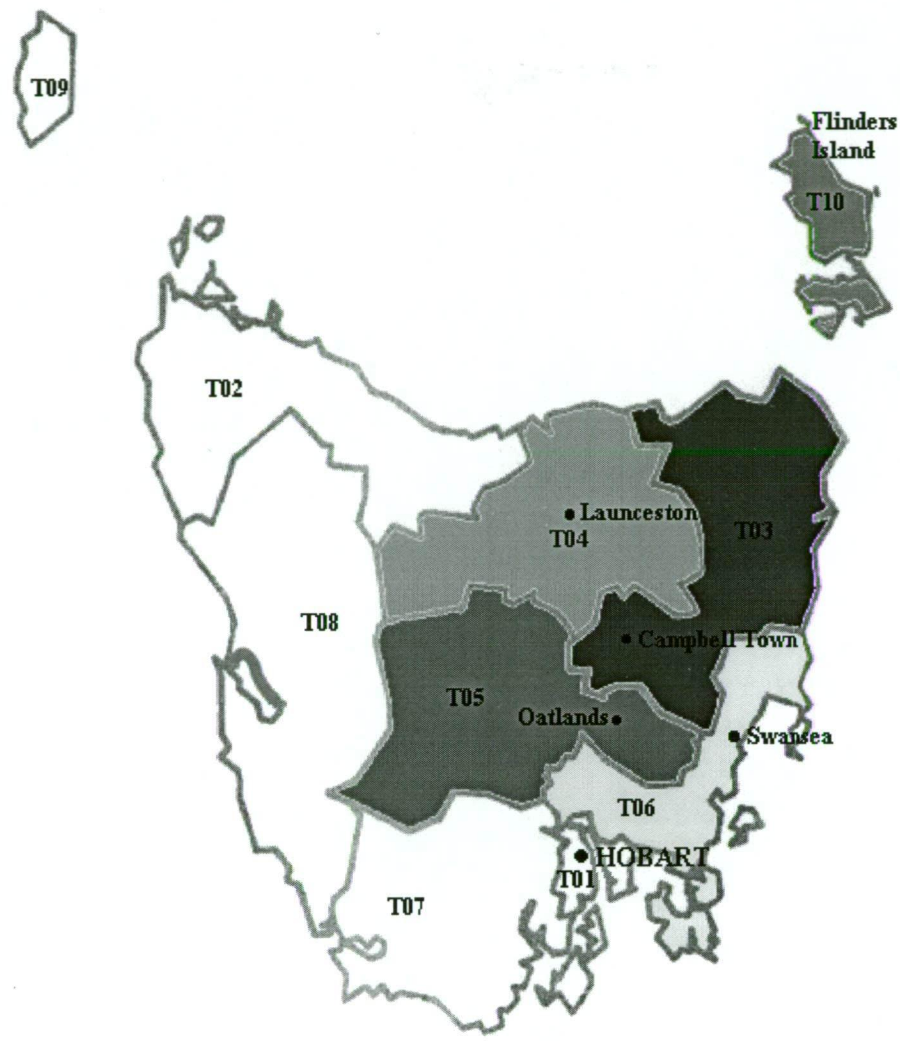


Figure 2.3: Tasmania's wool statistical areas.

2.5 Environmental and Physiological Factors Influencing Wool

Wool quality in sheep is affected by environmental stresses and the physiological state of the animal. The major determinants of wool growth are nutrition, climate and genetics. Wool growth is complicated by genetic factors such as genotype, age and gender of sheep, which influence both size and feed intake, and its reproductive status (Shaw and Findlay, 1990).

Wool production, fibre growth rate and fibre diameter vary throughout the year due to combinations of many factors including the inherent wool growth rhythm due to photoperiod, seasonal management and feed supply, changes in physiological status such as pregnancy and lactation, occurrence of disease and parasite infestations (Butler, 1992). The interaction of these factors and their effect on wool production is demonstrated in Figure 2.4.

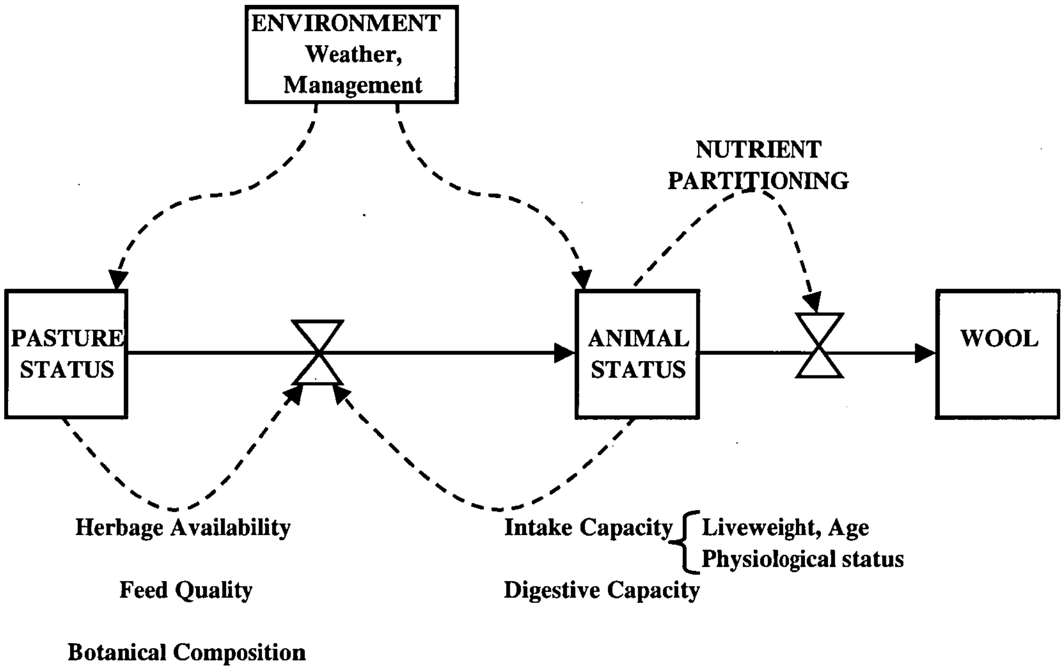


Figure 2.4: A schematic outline of the wool production system (White *et al.*, 1979).

Substantial seasonal and annual variations occur in both quality and quantity of wool grown by grazing sheep. These variations in wool production are largely a reflection of the nutritional status of the animal, combined with the effects of photoperiod, temperature, stress and disease (Williams and Schinckel, 1962; Allden, 1979).

2.5.1 Climate

The general weather conditions (climate) of an area will influence wool quality, either directly through climatic stress on the sheep or wool produced, or indirectly through the climate's influence on pasture production and hence feed consumption of the sheep. In Australia, seasonal change within an environment is the major factor influencing diameter changes along the fibre (Butler, 1994).

Weather conditions may increase or decrease wool growth by directly affecting metabolism at the wool follicle. The extent to which temperature stresses directly influence the productivity of the Tasmanian flocks is not documented, however the effects of extreme temperature stresses, both hot and cold, have been related to wool growth in numerous studies (Thwaites, 1968; Bottomley, 1979; Hopkins and Richards, 1979; Wallace, 1979; Weston 1979).

Heat stress may impair wool production in two main ways. By suppressing feed intake in adult sheep and hence lowering available nutrients, therefore limiting maximum wool growth. Heat stress may also impair the maturation of wool follicles in the foetus (Hopkins and Richards, 1979).

However heat stress has only been demonstrated to influence merino sheep that are not acclimatised to hot conditions, for example if sheep are moved from a temperate climate to a tropical climate. Therefore this will not affect Tasmanian wool production. Further research has demonstrated that prolonged heat stress, through its depressed effect on appetite, may severely depress wool growth rates in unacclimatised sheep.

Severe cold stress may also be detrimental to wool growth. Exposure to moderate cold will usually stimulate appetite and indirectly increase wool growth rate, whereas severe cold is likely to decrease wool growth (Hopkins and Richards, 1979), as cold stress modifies grazing patterns and reduces consumption. The extent of the change depends on body heat loss and, accordingly, is affected by fleece cover, environmental cooling, and various animal factors (Weston, 1979).

It has been found consistently that wool length growth rate rather than fibre diameter is retarded by exposure to the cold. In experiments conducted by Bottomley (1979) it was found that wool growth was retarded when temperatures were around 2°C for a minimum of four days and fleece cover was inadequate, likely if the animals had just been shorn. Conditions such as this may be of significance when temperatures are low for a number of days following shearing.

The degree of temperature stress conferred on the sheep by its environment is a function of climatic factors, including air temperature, wind speed, relative humidity and radiation (Bottomley, 1979), the general health of the animal as well as the insulation provided by body tissues and fleece.

Daylight can also have a direct effect on wool production as the seasonal rhythm of length of daylight is responsible for a part of the wool growth rhythm, and in particular is responsible for part of the low production in winter and spring (Coop, 1953). However, later research (Nagorcka, 1979) indicates that the effect of the photoperiodic rhythm in wool growth rate on wool production is of little commercial interest for most breeds, especially merinos.

Wet, humid climatic conditions can also have a direct influence on wool quality. It has been demonstrated that wool tends to discolour more in wet humid conditions however breed of sheep will influence the extent to which discolouring will occur (Thompson, 1988).

As well as directly influencing wool quality, climatic factors may indirectly alter wool quality through the climate's influence on pasture production. The botanical composition of the pasture and quality of the feed is influenced by climatic conditions and grazing management.

The level of wool production can be related to variations in the environment and in particular, to the climate-pasture interaction. The relationship between the type of pasture and the level of wool growth reflects (a) the distribution of rainfall throughout the year, (b) the ability of the vegetation to respond to rainfall and, (c) the amount of green forage available following a response to rain (Brown and Williams, 1970).

In Tasmania sheep are predominantly pasture grazed, either on native pastures or on sown pastures of introduced species. Climatic factors which determine the rate of production of both these pasture types are such that the amount of material presented to the grazing animal varies markedly both seasonally and annually, the variations being greater on the sown than on the less productive native pastures (Willoughby, 1959). The annual cycle of pasture availability to animals, which applies to Tasmania, is shown in Table 2.2.

Table 2.2: Annual cycle of pasture growth (Willoughby, 1959)

Summer	• Dry pasture • Excess mature growth from preceding spring, may be only material available to stock • Supply dwindles until effective rains re-initiate plant growth
Autumn	• If early rain occur, the growth rate of pasture may exceed animal demands • If rains are late pasture is less likely to grow rapidly enough to meet winter demands
Winter	• Any excess green feed from autumn is utilised • Excess feed is rarely sufficient quantity to fully supply livestock through winter • Slow or negligible pasture growth • Livestock experience a prolonged dietary deficiency
Spring	• Rapid pasture growth • Available pasture will normally exceed animal needs • Species mature and dry out as summer approaches

As can be seen in Table 2.2 rainfall in southern Australia is seasonal and the differences in the quality of pasture available during the dry summer period compared with the winter and spring period produce marked seasonal fluctuations in wool growth rate (Robards, 1979). In Australia, seasonal change within an environment is the major factor influencing diameter changes along the fibre therefore greatly reducing wool quality through lower staple strength (Butler, 1992).

2.5.2 Breed, Age and Sex

There are significant differences in wool production between sex, breed and age of sheep. In general, merino strains and bloodlines which produce higher fibre diameter wools have predominated in semi-arid areas and bloodlines producing lower fibre diameter wools have been run in higher rainfall areas (Rogan, 1995).

Low average fleece weights will occur in breeds where prime lambs or meat are the main output. These variations are partly due to difference in feed intake and the efficiency of utilisation of the diet of different breeds (Allden, 1979).

Wool production can alter substantially with increasing age of sheep. Several characteristics of the fleece such as weight, yield and staple length have been shown to decline with age (Mullaney *et al.*,1969).

In pregnant ewes it is possible that the nutritional demands of pregnancy and lactation might compete to a greater extent with those of wool production hence reducing the wool quality and rate of growth. The reduced wool growth is due to both a reduced fibre length growth rate and reduced fibre diameter with a resultant increase in the susceptibility to poor staple strength (Bigham *et al.*, 1983).

Corbett (1979) has shown that wool production of the breeding ewe is depressed by as much 10 to 14% compared with that of non-breeding ewes due to the demands of pregnancy and lactation. Pregnancy and lactation affect wool quality characteristics, including an increase in the incidence of cotting and 'break'. The occurrence of reduced wool production is especially likely in ewes rearing multiple lambs.

2.5.5 Nutrition

Nutritional status of the animal is dependent on feed quality and intake. Intake has a large impact on total wool production and is usually expressed by changes in both fibre length and fibre diameter (Coop, 1953; Mullaney *et al.*, 1969; Allden, 1979) and is influenced by:

(i) The pasture available to each animal within the flock depends on the amount and the botanical composition of the pasture, and the size and composition of the flock.

(ii) The animal's requirement for maintenance, pregnancy, lactation and growth.

(iii) The quality of the feed and the capacity of the animal to obtain nutrients from it.

(iv) Environmental factors such as the weather and some management procedures, which may influence the state of the animal, or of the pasture.

Various factors have been shown to interact to determine the performance of grazing animals. Intake was the major determinant but diet quality and the time spent grazing were both found to modify the response to intake (Birrell, 1981). The pasture characteristics with which changes in wool growth rate and liveweight appear to be most closely associated are the stage of growth, and the amount of available forage per unit area of land. A decline in the rate of wool growth is nearly always associated with the senescence and drying off of pasture. Liveweight does not usually decline for some months after the rate of wool growth declines (Williams and Schinckel, 1962).

The development of green feed, following autumn or winter rain, is usually associated with a marked response in wool growth rate and liveweight, particularly with Mediterranean-type species in southern Australia. Clearly, if an improved pasture merely reproduces the growth cycle of the natural pasture that it replaces, then very little more wool per sheep will be grown, although more sheep per area may be grazed. Responses in wool growth per sheep are likely to be observed only if the pasture species used in the improvement programme have very different seasonal growth patterns from those already in use (Williams and Schinckel, 1962).

Previous research (Doney, 1966) has shown that there are marked genotype/environment interactions in the response of wool growth to changes in feed level. Merino sheep seemed to be influenced mainly by changes in the quality and quantity of feed. However wool growth may not always respond to nutrition.

For example, Hawker *et al.* (1984), working with Romneys in New Zealand at latitudes similar to Tasmania, concluded that wool growth was relatively unresponsive to above maintenance feeding in winter. In contrast, research at lower latitudes showed that merino wool production is affected mainly by nutrition, irrespective of season (Williams, 1964), and in Western Australia, the seasonal wool growth pattern was reversed when the seasonal feed patterns were reversed (Butler and Head, 1993). From this research it can be observed that the same amount of feed provided to a sheep may result in different rates of wool growth according to both season and genotype.

2.5.6 Health

The effects of parasites and disease on wool production may range from complete shedding of the fleece to a modest reduction in the amount of wool grown, and are qualitatively similar to those of nutritional changes, reflecting reductions in fibre diameter and length growth rate of varying severity and duration. Thus, a short acute illness may lead to a temporary, pronounced reduction in fibre diameter sufficient to cause a break in fibres during manufacture, but not sufficient to produce a significant reduction in fleece weight at annual shearing. At the other extreme, chronic, low-grade infections may result in the production of shorter, thinner fibres over an extended period reflected in a lighter fleece without 'break' (Donald, 1979).

Blowfly strike is generally acknowledged to reduce wool production and staple strength, the reduction depending on the extent of the struck area. Internal parasite infections have a large and well documented impact on reducing fleece weight, fibre diameter, staple length and increasing the incidence of tender fleeces (Butler, 1994).

Therefore the general health of the flock is very important to maintain good wool quality throughout the year.

2.6 Wool Characteristics and their influence on wool quality

The quality profile of Australian wool production is currently defined in terms of fibre diameter, style, staple strength, staple length, vegetable matter content and scoured colour. These characteristics accounted for 92% of the variation in the clean price of merino fleece wool sold at auctions in Australia (Jan – Mar, 1995) (IWS, 1995).

The performance of wool processing is influenced by variations in wool characteristics (Figure 2.5). Wool is generally sold in Australia under a sample description, which includes both objective measurement and subjective appraisals of raw wool characteristics that are important in processing. Buyers use the objective test data information provided, together with their own subjective appraisal of the sale sample, to value the wool based on an estimate of its processing performance (Gleeson *et al.*, 1993).

Characteristic	Importance
• Yield	****
• Fibre Diameter	****
• Vegetable Matter	***
• Length	***
• Strength/Position of Break	***
• Colour/Coloured Fibres	***
• Fibre Diameter Variability	**
• Length Variability	**
• Degree of Cottedness	**
• Resistance to Compression	**
• Style	**
• Handle	*
• Breed	*

Figure 2.5: Importance of greasy wool properties in processing to top (Cottle and Bowman, 1991)

Presale objective measurements of those characteristics which most influence the selection of processing and product options were introduced to assist wool buyers identify lines of wool meeting processors' specifications (Ive *et al.*, 1988). The industry is progressing towards using objective measurements rather than subjective as they provide consistent results and allow better comparisons between years. At the present fibre diameter, fibre diameter variability yield, vegetable matter, length, strength and colour may all be measured objectively if required.

In the past Tasmania has been slow to adopt new testing procedures compared to mainland Australia. However, this trend has been reversed with the introduction of an objective test for clean colour. Tasmania currently leads the nation in the adoption of this new test (DPIWE, 1998).

2.6.1 Fibre Diameter

Fibre diameter has the most significant influence on wool prices, as finer wools can be spun to finer yarns and processed into lighter weight, higher value products. Analysis of prices for merino fine combing fleeces show that mean fibre diameter has consistently been the most important characteristic that determines the clean price of raw wool. It has accounted for at least 80% of the variation under a range of market conditions (Andrews *et al.*, 1997).

Wool fibre diameter has always been appraised by relying on the relation between staple crimp frequency and mean fibre diameter. However crimp frequency is a poor predictor of mean fibre diameter of single fleeces, particularly for finer wool (Cottle and Bowman, 1991). Therefore all wool is measured objectively for fibre diameter and the micron of the fleece is recorded on the test certificate.

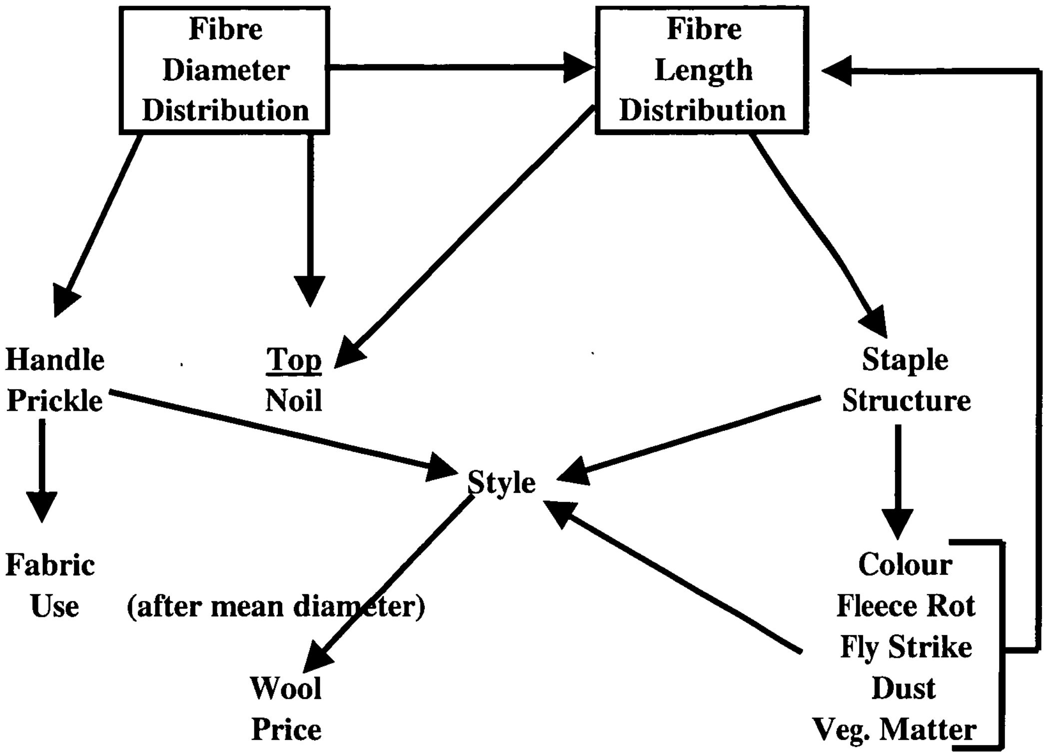


Figure 2.6: Relationship between fibre diameter, fibre length, production traits and wool quality (Lax *et al.*, 1990).

Many experimental results indicate that there are relationships between fibre length growth rate and fibre diameter within the staple (Corbett, 1979; Allden, 1979). Lax *et al.* (1990) suggested that fibre diameter distribution is the major genetic factor in all aspects of fleece quality that are of significance to the sheep breeder with major economic effects both on farm and in manufacturing. These interrelationships are summarised in Figure 2.6.

Diameter differences occur between sheep within a flock. However, this is not the only variation that occurs, variation or fibre diameter variability occurs within a fleece and this produces an individual wool clip comprised of fibres of varying diameter (Crook *et al.*, 1994).

Fibre diameter variability (FDV) is an inherent characteristic of all fleeces, this variability continues throughout the intermediate stages of processing and carries through to the finished wool product. Variability within the fleece arises from:

- Variability along the length of individual fibres in response to environmental fluctuations;
- Variability in diameter between fibres;
- Gradients in diameter from shoulder to rear and from back-line to belly.

The structure of the growing fleece deteriorates with increasing FDV with affected fleeces displaying poor crimp and staple definition, pointed staple tips and/or protruding coarse fibres. Pointed and hairy tips are said to increase the penetration of dust and water into the fleece while poor crimp and staple definition are thought to retard drying of the fleece after wetting (Taylor and Atkins, 1992). This may lead to discolouration of the fleece.

Lax *et al.* (1990) indicates that fibre diameter distributions have an important role in several aspects of wool production and sheep breeding. They clearly are involved in resistance to fleece rot and fly strike, have relationships with staple strength and harsh handling wool, and may be important in resistance to weathering and dust penetration. The high heritabilities of fibre diameter variability indicate that it could be changed rapidly where required through breeding.

Variation within a fleece is caused by exposing sheep to different environment and physiological effects (Hansford, 1992). If sheep are feed a constant ration all year, wool growth will still vary along the fibre (a range of about 1 to 3μm) resulting from environmental conditions affecting wool growth. However, when sheep are exposed to environmental effects such as pregnancy and lactation, this variation is increased and ranges of 4 to 8μm are frequently observed (Hansford, 1992). If the along-fibre variation is high, strength of the wool is reduced, and it is most likely to break at or around the point(s) of low fibre diameter. Table 2.3 shows that the 'within staple, between fibres' component is the major source of variation in diameter, however, its importance diminishes if the wool is tender. The variation along fibres contributes proportionally more to the overall variation.

Table 2.3: Relative sources of variation within a mob for mean fibre diameter (Hansford, 1992).

VARIANCE OF DIAMETER WITHIN A MOB (Component as % of Total Variance)		
Source of Variation	Percentage of Total	
	Sound	Tender
Within the staple between fibres	64	43
Within the staple along fibres	16	43
Within the fleece between sites	4	3
Among fleeces	16	11
	100	100

It needs to be emphasised that regardless of any other effect of fibre diameter distribution, the along-fibre variation is important because it determines not only the wool strength but the position of break, which in turn impacts on the early-stage processing performance and the Hauteur or fibre length after processing (Hansford, 1992).

Changes in fibre diameter between years primarily reflect variation in seasonal conditions. Research (Rogan, 1995) has shown that a higher proportion of finer wools occur in years of poorer feed quality and quantity. Fibre diameter varies between breed strains and bloodlines, an accurate account of this variation is demonstrated in recent wether trials. Wether trials first started in Tasmania in 1997 and involve small groups of wethers of comparable age, from different flocks and representing different merino bloodlines being brought together and managed identically for periods of 1 to 3 years. As sheep were run together they are free of confounding effects of management and environment. Therefore allowing more direct comparisons of the inherent productivity and wool quality between bloodlines.

2.6.2 Yield

Yield is used to estimate the quantity of useable wool fibres present and is expressed as a percent of weight of the original raw material. Greasy wool contains a number of components, apart from wool fibre. These include vegetable matter, dust, moisture, grease, suint and mineral matter. When the price to be paid for greasy wool is being set, it is important to know the amount of clean fibre present. Yields allow this estimate to be made. Yields are given for various stages and types of processing. The most common yield used is the 'Schlumberger dry combed top and noil yield' (Cottle and Bowman, 1991).

Yield is of vital significance during the early stages of processing but has little or no significance after scouring has been carried out. The subjective determination of yield is difficult as within mob yields differ due to different amounts of grease and suint content and due to the hygroscopic nature of wool, it may absorb up to 30% of its weight in water.

Yield is employed in the calculation of the price of all greasy wool. A yield percentage enables ready conversion from clean to greasy price or vice-versa. Three test yields appear on each lot of combing wool in sale catalogues, these are estimated yields, the actual yield can only be determined when processing results are known (Cottle and Bowman, 1991).

On a state basis, the Tasmanian wool clip is generally the highest yielding (71.3%) of all states (national average is 65.1%). One reason for high yields of wool within Tasmania is the low vegetable matter content. However, the bulk of regions within Tasmania do not differ markedly form the national profile for yield (Tasmania Industry Wool Situation, 1999).

There has been little research carried out on the changes in yield through management of the sheep flock. Story and Ross (1960) determined that the clean yield of pre-lamb-shorn wool is usually higher than that of post-lamb-shorn. Two of the most probable factors causing this are that wool growing in the period September to November has a lower suint content in the case of the pre-lamb-shorn, and secondly at the time of dipping in February to March, the pre-lamb–shorn sheep are carrying three months' more wool which is exposed to leaching during dipping.

Management has been found to have little influence on yield. The genotype or breed of sheep has a large influence on yield of wool, in general higher yields are usually associated with coarser and longer wools (Rogan, 1995).

2.6.3 Style

In fleece wools, style refers to the general quality of the wool. There are two main categories as far as style is concerned, Spinners and Topmakers. Spinners wools are bulky, bright wools containing little if any dust and very little vegetable matter. Topmakers wools have faults that exclude them from the spinners style and these faults are usually dust and vegetable matter but colour may also be included. The spinners style is further divided into three; choice, superior and spinners in descending order of excellence. The topmaking style is further divided into best, good, average and inferior with the type and degree of dust forming the basis of which style category is applied. The style gradings take into account the average fibre diameter and the greasy staple length. The Australian Wool Corporation developed a chart of type numbers ranging from 1 to 800 which allows each type to be described by a number, this was the most widely used and understood style appraisal system. However, there is now a new classification system put in place by Australian Wool Exchange with just seven classifications for merino combing wools.

Visually, wools in the various style grades are quite different. This is obvious from the overall appearance of lots as well as from individual staples. Staples of good style have attributes representing good character and avoidance of environmental damage and contamination. Staples from wools of an Average or Inferior Topmaking grade are generally of poorer character and are more heavily contaminated by dust or more damaged by environmental conditions. These are consequently worth less in monetary terms although the discounts vary according to the mean fibre diameter (Jackson and Rottenbury, 1994).

Style variations, as seen between sale lots on the show floor, are mainly a reflection of environmental factors (dust, water, vegetable matter, temperature effects on yolk colour) but there can also be differences due to breeding (crimp frequency, character, colour, staple structure).

Research has shown (Jackson and Rottenbury, 1994; Ford and Jackson, 1994) that style can be regarded as a product of both breeding and the environment. It can also be perceived as an interaction between the production of a fleece with a particular type of structure, and the environmental conditions encountered which lead to contamination and fibre damage (Jackson and Rottenbury, 1994). However, wool style could be considered as the interaction between the fleece as grown and the conditions under which it was grown.

Style was once considered important by the trade for predicting processing performance. As it was thought that through increased measurement, to isolate particular characteristics of wool such as length and strength, it is also possible to determine the effect of the residual characteristic of style on processing (Winston, 1988). However, the production aspects of wool style have largely been separated from the processing aspects, with style largely a reflection of the environment (Ford and Jackson, 1994).

2.6.4 Colour

Wools are either objectively measured or subjectively assessed and graded for colour into one of the following types:

- No colour
- H1 fault - light unscourable colour
- H2 fault - medium unscourable colour
- H3 fault - heavy unscourable colour

The clean colour of wool, that is the base colour of the fibre, is important because it limits the colour the wool can be dyed to, without bleaching (Teasdale, 1989). For example, the lighter the colour of the fibre, the greater the number of the shades to which it can be dyed. In greasy wool, the colour of the fibre base is masked by contamination such as grease, suint, vegetable matter and dust. Most of these are removed during processing. There may also be staining caused by agents such as urine or bacteria, which is difficult or impossible to scour out.

Commercially available objective colour testing for yellowness only recently became available however Tasmania leads the nation in the adoption of this new test (*pers com.* A.Bailey). The availability of colour measurement provides an important link in allowing the true processing potential of wool to be realised (Teasdale, 1989).

Clean colour specification is becoming very important for wool marketing as research has demonstrated that the subjective assessment of clean colour from appraisal of greasy wool can be unreliable. It is estimated (Teasdale, 1988) that Australian wool is discounted about 0.4% of its value because of appraised unscourable colour. This represents up to $20 million per year in discounts on current wool prices.

Until recently the colour of wool was routinely appraised subjectively. Because of the difficulty of predicting clean wool colour by examination of samples of greasy wool, such appraisals have tended to be cautious; sale lots are often downgraded, and discounted in price, because of the presence of small amounts of coloured fibres which would not affect the colour of the scoured carded wool (Teasdale, 1989).

The clean colour of greasy wool is measured after scouring, blending and the removal of contaminants, such as vegetable matter, as wool must be processed to a clean state comparable to that of the final product before the colour can be measured (Teasdale, 1988). An objective colour measurement will assist in ensuring that only wools with unscourable colour are discounted (Thompson, 1987).

Research has shown (Thompson, 1988; Rogan, 1995) that the environment plays a large role in the discolouration of wool. It is documented that high rainfall may induce yellowing and staining in the wool especially if combined with humidity.

There are three main types of discolouration associated with the environment:

"Butter" colour	Substances in the wool auto oxidise to yellow/brown, and thus all wool will discolour in storage to some extent. Most of the colour is scourable.

Canary Yellow	This is associated with damp, warmth, and high alkaline suint content. Since suint is washed down the back towards the lower part of the fleece, canary stain is particularly found in the bellies and places where the fleeces are most dense. Where the grease has been washed out by rain and the fibre has swollen with the moisture, the colour becomes fixed into the fibre, but where there is plenty of grease most of the colour may scour out.
Bacterial Stains	Types of bacterial stains are also called fleece rot, water stain, weather stain etc.. These are caused by colonies of bacteria, which multiply in warm, damp conditions such as at the base of the fleece when the wool is wet. Thus the stains often occur as bands within the wool. Some bacterial stains are scourable but may occur with unscourable canary stain. Stains are usually yellow but may be green or brown.

Wool colour is also influenced by breed of sheep, crossbred sheep have fleeces which are generally less bright and white than merinos (Rogan, 1995).

Atkins *et al.* (1994) demonstrated substantial variation between merino bloodlines in greasy colour, there being a tendency for bloodlines of higher fibre diameter to have higher scores for discolouration. Hence it has often been reported that the grower can do little about the colour of wool except possibly select breeds or strains less prone to discolouration.

2.6.5 Staple Strength

Staple strength is the most important characteristic, after fibre diameter, contributing to variation in the clean price of merino fleece wools sold at auctions in Australia (IWS, 1995). It is expressed as the force required to break the weakest point in the staple divided by the average linear density or thickness (g/m) of the whole staple

(N/ktex), fibres with a high variability in diameter along their length will produce weaker staples than uniform fibres (Masters *et al.*, 1998).

Low fibre strength is becoming widely recognised as a major problem for merino wools. The wool fibre is now weaker than many synthetics, and as the speed of manufacturing increases, price penalties for low staple strength are being imposed above the traditional limit of 25-30 N/ktex. The average strength value for sound wool in Australia is now 38 N/ktex (IWS, 1997/98). Currently, a quarter of all Australian merino wool is penalised for low staple strength. Fibre strength must be improved if the wool industry is to maintain its position in the market (Adams, 1994).

Up until recently the majority of wool was subjectively measured for staple strength. At present around 90% of the Tasmanian fleece lines are objectively measured for staple strength (*pers com.* M.Best).

Wools of strength greater than 25 N/ktex are difficult to assess subjectively, whereas to a manufacturer, the objective information delineating the strength of these sound wools could be commercially exploited. Therefore, it can be presumed that a price differential will appear in the market place as more wool is sold by description, with premiums for the upper levels of strength and discounts for the very low levels. Management strategies employed by the producer may need modification or alteration to avoid the evident stress periods that could produce a lowering of tensile strength with a consequent lowering of value for wool production (Butcher *et al.*, 1984). Staple strength of Tasmanian wools, although generally in the sound range, could be improved, leading to better processing performance.

A variety of physiological and environmental factors are known to influence the strength of wool fibres, but the compositional and structural characteristics of the fibre that are associated with weakness are still poorly understood. The differences in staple strength can be regarded as an indication of large differences between sheep in the intrinsic strength of wool fibres comprised within the staple (Reis, 1992).

The strength of a wool staple is dependent on the intrinsic strength of the fibres that it contains and the total cross-sectional area of fibre being tested (Gourdie *et al.*, 1992; Reis, 1992). Staple strength appears to be related mainly to seasonal variation in average fibre diameter along the staple, diameter generally being least at the point of break (Butler and Head, 1993). Large differences in intrinsic strength occur between fibres of similar diameter.

The minimum fibre diameter does not account for all the variation in staple strength, as the rate of change in fibre diameter along the staple is the main determinant (Butler and Head, 1993). A major reason for low staple strength is the variability in fibre diameter associated with the seasonal changes in pasture availability and quality.

Low staple strength may be caused by environmental stress but it also has a genetic component which means it can be improved by selection (Lewer and Li, 1994). Staple strength has a heritability of 0.4, similar in magnitude to that of fleece weight, so genetic selection offers a valuable means to improve staple strength. However, the staple strength selections are not straightforward. Growers will need to know which aspects of sheep management give rise to variation in these characteristics (Thornberry *et al.*, 1988).

The rate of change in fibre diameter is influenced by the body reserves of nutrients such that sheep with a low condition score show a greater rate of change in fibre diameter of their wool following sudden changes in nutrient supply and a greater reduction in staple strength than sheep with a higher body/condition score. Because changes in fibre diameter can be associated with changes in the nutrient supply, rapid alterations in nutrient availability may be expected to increase the rate of change in fibre diameter and thereby alter staple strength. Minimum liveweight, minimum fibre diameter and maximum change in fibre diameter were all contributing factors in staple strength problems in previous research (Earl *et al.* 1994; Peter *et al.*, 1994).

In paddock-grazed sheep, the position of staple break will be a function, firstly, of the impact of both physiological and environmental conditions, which do not necessarily occur at the same time (e.g. the autumn break and spring lambing) and secondly, of the time of shearing. The importance of variation along fibres needs to be emphasised because of its large effect on staple strength and position of break, as these quality characteristics of raw wool have a definite impact on processing performance. Therefore an understanding of the wool growth factors which can influence staple strength is valuable (Hansford, 1992). Shearing at the point of break minimises the effect of this reduction in staple strength on processing performance (Arnold *et al.*, 1984).

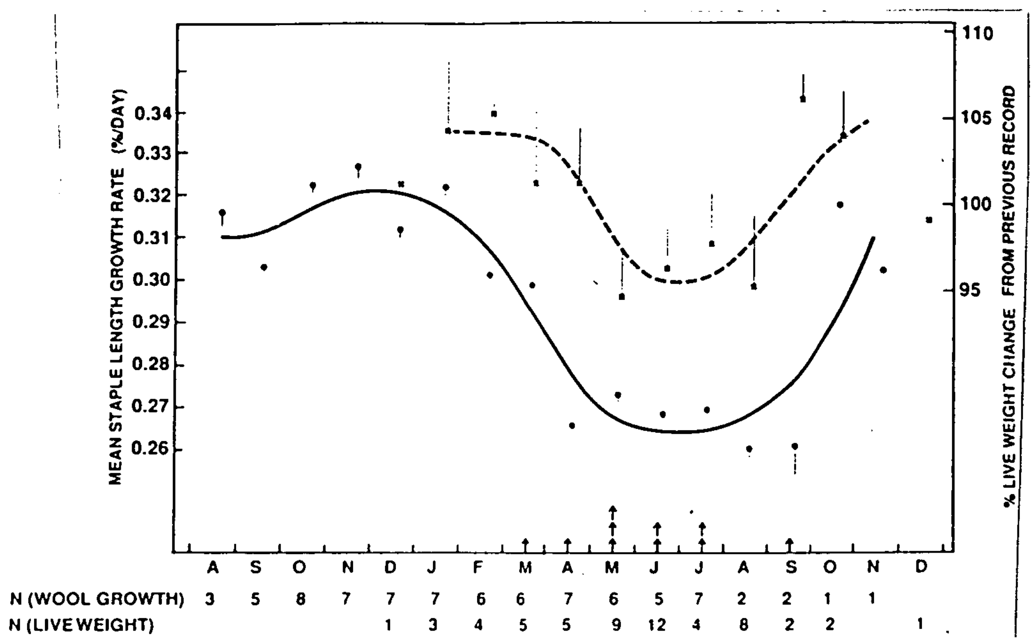


Figure 2.7: Seasonal wool growth rates, liveweight changes and time at which staple break occurred (Butler, 1992).

Research by Butler and Head (1993) found that some flock owners identified a management event, which may have influenced the position of break. Stresses identified included the break of season, short term feed stress and the start of lambing. When each position of break was matched with its district rainfall pattern it generally occurred during, or immediately following, a period of average or below average rainfall.

Position of break in the staple generally occurred during the period of lowest fleece growth rate in autumn and winter while the peak growth rate was in spring, for 20 animals per flock in nine Tasmanian flocks (Figure 2.7).

Staple strength also varies over the body of the sheep (Bigham *et al.*, 1983) being strongest on the neck and weakest on the back. Back wool is usually the most weathered wool, which may account for its low intrinsic strength.

The inherent rhythm of wool growth in Tasmania is about 40%, of similar magnitude to the seasonal wool growth rhythm and within the range for sheep in Australia, suggesting that manipulation of nutrition can influence wool growth and staple strength. The trough of wool production and position of break tend to occur in autumn-winter in Tasmania (Figure 2.7). Increased stocking level, submaintenance winter feeding and winter feeding of forage crops all increase the incidence of fleece tenderness in flocks of mature sheep (Bigham *et al.*, 1983). Possible management strategies to improve staple strength include choice of shearing date to coincide with the position of break, manipulation of feeding regimes to better match feed supply with animal requirements, and possibly breeding for lower seasonality of wool production (Bigham *et al.*, 1983; Butler, 1992).

It may be possible to improve staple strength by evening out the seasonal wool growth pattern through manipulation of feed supply. By increasing feed intake during the winter feed trough and/or reducing feed intake in the spring flush. Although the basis of variation in staple strength appears to lie in seasonal patterns of wool growth, other factors are also implicated and include intrinsic strength and minimum diameter of the fibres, total variation in fibre diameter, and rate of change in fibre diameter along the staple (Butler and Head, 1993). Changes in the supply of nutrients to wool follicles would be expected to influence both intrinsic strength and diameter of fibres. The practical importance of the effects of the supply of specific nutrients to fibre strength remains to be determined (Reis, 1992).

The outstanding feature of research work in Tasmania (Butler *et al.*, 1994) is the increase in staple strength when wethers were shorn in July instead of November regardless of whether they were subject to ewe or wether flock husbandry. The increase in staple strength is probably due to the July shearing being close to the winter feed deficit. Therefore there is potential for farm managers to manipulate their wool quality and potential returns, provided a change in shearing date is acceptable to their management program. Choice of best shearing date could readily be made by farm managers on the basis of staple measurements of wool from groups of their own sheep shorn at various potentially acceptable times, but otherwise treated identically to the rest of their flock. Gains of the order of 12 N/ktex might be made in this way.

The improvement in measured strength gained by moving shearing from November to July presumably arose because, at least in a substantial proportion of wethers, the point of weakness was now so near the tip of the staple that the weak point was clamped during the measurement, thus forcing the break to occur at some other, stronger point. This is indicated by the increase proportion of mid-staple breaks recorded for the July shorn, compared with the November shorn wethers (Butler *et al.*, 1994).

The simple option of altering shearing date is not always practicable and improvements in staple strength may require the more onerous adjustment of feed supply or other aspects of husbandry.

Staple strength can also be improved by changes in flock husbandry. Butler *et al.* (1994) have shown wethers run in the ewe flock had stronger staples than equivalent wethers run in the wether flock. This was so, regardless of whether they were shorn in July or November and was presumably due to the more favourable husbandry applied to the ewe flock.

In Tasmania the potential time of shearing and flock management to improve staple strength have been documented (Butler *et al.*, 1994) as well as the difficulty in producing high quality wool under conditions of variable nutrition. The work confirms that time of shearing is a useful management tool for improving staple strength, but also indicate that other management strategies should be considered. Further it shows that reproduction is no barrier to producing sound ewe wool in Tasmania, at least if shearing time is suitably chosen in relation to the environmental conditions.

2.6.6 Vegetable Matter

Vegetable matter is found in all Australian wool in varying amounts depending on the season and locality. About 44% of the Australian clip is classed as being free or nearly free (FNF), having less than 1% vegetable matter present in the greasy wool (Atkinson, 1989). There is no overall long-term trend either upwards or downwards for the amount of vegetable matter present in the wool (Lunney, 1981). The variation and extent of vegetable matter content across the years and regions is due to a number of factors such as composition and growth characteristics of the pastures being grazed.

Vegetable fault contamination is the major price determinant of the relative clean price of wool after fibre diameter, as it increases wastage during carding and combing and failure to remove it during processing results in rejection or costly mending of fabrics (Whiteley, 1990). Research shows that the greater the amount of vegetable matter present initially in raw wool (i.e. the higher the vegetable matter base) the greater the subsequent contamination of the top and fabric (Atkinson, 1989).

Vegetable matter classification is divided into three major categories:

1. burr (vm1)
2. seed/shive (vm2)
3. hard heads and sticks (vm3)

Each category has different requirements and implications for processors.

The consequences of vegetable matter on processing vary enormously dependant on type and quantity and the form of processing, (carding or combing). Some types of vegetable matter are virtually inoffensive while with other types, even a relatively small infestation can be disastrous in a particular form of processing (Johnston, 1992). Due to the finer and more supple nature of species such as spiral burr, seeds and grasses these types of vegetable matter are difficult to remove in carding. They therefore tend to be transferred through gilling to the combing stage where they are largely taken out. However vegetable matter removal at this stage inevitably leads to fibre loss (Bow *et al.*, 1989). Hardheads are relatively easily removed from the fibre during carding.

To lessen the effects of vegetable matter contamination improved description of vegetable matter contamination is essential if the wool industry is to adapt to future economic pressures. Wool alone, among the world's fibres, suffers from significant costs due to the need to remove vegetable matter faults from the fabric. Vegetable matter contamination problems can be addressed in two major ways; by improved efficiency of removal and by better description of the types of vegetable matter present (Atkinson, 1989).

Vegetable matter content, expressed as a percentage of clean wool weight, is routinely objectively measured prior to sale. The wools are then graded for sale into a number of different types, which are determined by the amount, and type of vegetable matter present:

Free or nearly free (FNF)	-	up to 1% vegetable matter
B fault	-	1.1% to 3% burr
C fault	-	3.1% to 7% burr
D fault	-	greater than 7% burr
S fault	-	1.1% to 3% seed
L1 fault	-	3.1% to 7% seed
L2 fault	-	greater than 7% seed

The major contributor to variation in the extent and type of vegetable matter contamination in wool is the composition and growth characteristics of pasture grazed by the sheep. In general, wool grown in high rainfall, temperate areas contain lower vegetable matter contents than wool grown in semi-arid, pastoral zones. This is apparent by the relatively low levels of vegetable matter contamination of Tasmanian wools (Table 2.4).

Table 2.4: Percentage of bales in Tasmania sold at auction within each vegetable matter description between 1989/90 to 1991/92 (Rogan, 1995).

% of total bales sold at auction				
Year	FNF	light burr/seed (B and S fault)	Medium burr/seed (C and L1 fault)	Heavy burr/seed (D and L2 fault)
1989/90	75.0	13.4	1.1	0.0
1990/91	72.4	14.5	1.4	0.1
1991/92	66.9	17.6	3.1	0.4

The level of vegetable matter present within wool can be considerably reduced by fleece preparation procedures after shearing. The removal of bellies, along with the locks and stains, reduce the vegetable matter content of the fleece lines by approximately 1% with a further reduction of 2% being achieved by skirting. However, this removal of almost half the vegetable matter from the fleece effectively concentrated the vegetable matter in the non-fleece wool lines which collectively had vegetable matter contents double that of original shorn fleece (Charlton *et al.*, 1985).

Mechanical methods such as carding and combing are one way in which vegetable matter can be removed from the wool. This method avoids the problems associated with chemical removal. In the worsted process, vegetable matter is removed deliberately during carding and combing but adventitious loss occurs during all stages, notably spinning. Because combing is the last stage of deliberate vegetable matter removal, subsequent loss of vegetable matter is important, even though only a small percentage of the original vegetable matter has remained in the top after combing (Atkinson, 1989; Anson, 1985).

Carbonising or acid treatment is another method to remove the vegetable matter and can be used to treat either the loose wool or the final fabric. Loose wool carbonising is normally confined to wools intended for the woollen process where the deleterious effects on fibre strength, fabric softness and colour are less critical (Atkinson, 1989).

In principle there are several ways in which vegetable matter contamination in greasy wool might be reduced through controlled pasture grazing, rugging of sheep or changing of shearing times but as vegetable matter is not a huge economic burden these methods are largely impractical.

2.6.7 Staple Length

The two most important fibre characteristics for a worsted spinner are average fibre diameter and fibre length (known as 'hauteur' in wool top). A challenge for woolgrowers is to be able to reduce fibre diameter and enhance those factors, which, collectively, will increase hauteur. (Ward, 1998). One difficulty is the sheer complexity of the interactions that determine hauteur and the uncertainty that creates when determining the consequences of changes to wool traits. Fibre length also has a role in determining the method of manufacture and processing behaviour and may effect the amount of nep and noil (Lax *et al.*, 1990).

Although hauteur is a vital measurement for the spinner, it cannot be measured directly on the raw wool. The process of top-making (scouring, carding and combing) breaks many raw wool fibres, reducing the average fibre length, creating noil, and increasing the variability of fibre length. The hauteur thus depends on the initial fibre length, and the degree to which the wool fibres break during processing. Fibre breakage depends on a number of factors in the raw wool, and on the settings of the processing machinery (Adams and Oldham, 1998).

Variation in length may be a significant contributor to staple strength variation (de Jong *et al.,* 1985 cited by Schlink *et al.,*1998), however experiments carried out by Schlink *et al.* (1998) could not demonstrate that fibre length variation contributed to the difference between the staple strength genotypes.

In Tasmania the spring flush of feed generally occurs prior to December, before the staple length growth rate appeared to peak. This suggests that seasonal influences resulted in no apparent change in staple length growth amplitude (Figure 2.8). Similarly, the greatest feed deficit period is generally just after the June/July trough in staple length growth rate (Butler and Head, 1996).

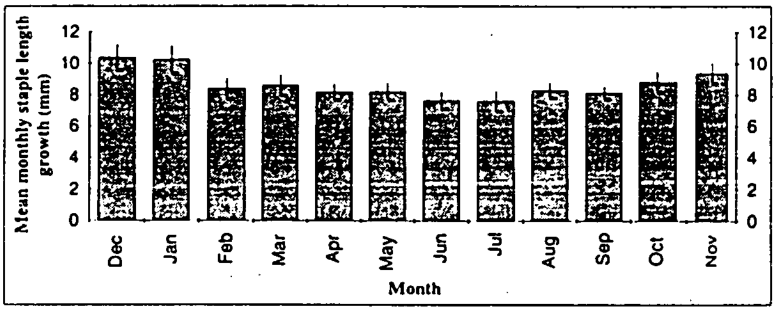


Figure 2.8: Mean monthly staple length growth rates for all Tasmanian seasonal wool data combined. Vertical bars represent standard deviation (Butler and Head, 1996).

2.7 Summary

The quantity and quality of the wool produced, throughout both Tasmania and Australia, are influenced by numerous physiological and environmental factors. Wool production also varies significantly between different geographical and climatic areas. The changes in sheep populations and wool measurements have been examined as well as the influence of wool characteristics on price and how the quality is measured and influenced by outside factors. This study aims to clarify the reasons for these changes in both wool quality and quantity within Tasmania and similar wool producing regions of 'mainland' Australia.

The physiological and environmental influences on wool characteristics examined in this chapter will allow analyses of the changes in Tasmanian, NSW and Victorian wool quality in the following Chapters.

Chapter Three: Methods and Materials

3.1 General Characteristics of Tasmanian Wool

In order to determine the characteristics of the Tasmanian wool clip, data from the 1991/1992 to 1996/1997 seasons was analysed. Wool International holds Australian wool test results from wool presented for sale at auction. Wool data for all Tasmanian WSA were purchased from the available Australia-wide data set. Thirty-two relevant fields were chosen from the catalogue information system for the analysis in the current study. These fields are shown in Table 3.1.

Data was made available by Wool International as ASCII text files and was converted into Microsoft® Excel (Microsoft Corporation, Redmond Washington, USA) documents. Data manipulation was then performed using Microsoft® Excel. Each season's data was manipulated individually.

There are ten Wool Selling Areas (WSA) within Tasmania (T01, T02, T03, T04, T05, T06, T07, T08, T09 & T10), as well as allocations for interlotted (T98) and bulkclassed lots (T99). Both T99 and T98 were not analysed, as origin of wool in these categories is unknown.

From the ten Tasmanian WSA the five highest producing areas (T03, T04, T05, T06 and T10) were selected for further analysis. These five areas produce approximately 90% of Tasmania's wool. The remaining areas not analysed were T01, the Hobart area, T02, North West Coast, which is mainly forestry and dairy, and T07 and T08, which are largely wilderness and T09, King Island, which supports mainly dairy and beef production.

Each of the selected WSA information was copied and recorded into separate Microsoft® Excel workbooks. Data was filtered using the 'mircat' field category (Table 3.1). The 'mircat' field consisted of four categories:

1. Merino Fleece
2. Crossbred Fleece
3. Skirtings
4. Cardings

Table 3.1: Fields purchased from Wool International and used in analysis

Field	**Description**	***Example***
Brand	A free format 30 characters identification of the wool growing property from which a lot component came. It appears on the bale packaging.	Seaview
Buyer	A code uniquely identifying a wool buyer.	ITO= Itochu
Clipprep	A code identifying the preparation of the lot.	0 = growers
Colfault	A code identifying subjectively assessed colour fault in the wool.	H1
Lastbid	The highest or last bid on a lot expressed in c/kg greasy, to 2 decimal places to allow for previous seasons' quarter and half cent bids. The last bid is the selling price (to the trade or Australian Wool Corporation), unless the lot is passed in and not subsequently claimed.	505c/kg
Lastbidcln	This is the lastbid clean. It has been added to simplify queries, and is derived from the lastbid figure. It is lastbid multiplied by 100 and divided by the yield.	652c/kg
Lot_bales	The total number of bales within a lot.	
Lot_gross	The gross mass of the lot, expressed in kg. It is a sum of the net and tare weight, plus the sample weight.	724kg
Lot_seqno	This is a surrogate identification key for a lot.	314005
Micr	The mean fibre diameter of the lot. It is measured by a test house and is reported on a core test certificate as a numeric quantity to the nearest 0.1 μm.	18.7μm
Mircat	This is a code identifying the type of wool present e.g. Merino fleece, skirtings, cardings and crossbred fleece.	1 = merino fleeces
Mof	This is a code identifying the method of offer, under which the wool is offered for auction.	1 = sale by sample
Pobbase	Position of Break in the base region of the staple determined by the percentage of staples submitted to ATLAS testing which break at the base. This numeric quantity must be between 0 and 100.	19
Pobmid	Position of Break in the middle region of the staple, which is determined by the percentage of staples, submitted to ATLAS testing which break at the middle. This numeric quantity must be between 0 and 100. Mid section breaking is used in classifying tender wool.	66
Pobtip	Position of Break in the tip region of the staple determined by the percentage of staples submitted to ATLAS testing which break at the tip. This numeric quantity must be between 0 and 100.	15

Purind	A code identifying a purchase indicator, whether the lot was passed in or trade purchased.	2 = Trade Purchase
Sellbrk	A code identifying the broker responsible for selling the lot at auction.	ROB = Roberts Ltd.
Sellcen	Codes identifying the selling centre where the lot was sold.	LAU = Launceston
Series	The sale number within a season for a particular selling centre.	2 = second sale
Staplen	The mean staple length of greasy wool as measured by ATLAS. It is the average length of a staple from the tip to the base. The average staple length is reported in millimetres.	97 mm
Staplen_cv	This is the coefficient of variation of the staple length measurement (%).	17%
Stapstr	The staple strength (expressed in N/ktex). It is the force or "pull" (Newton) required to break a staple of given thickness (Kilotex). It is a measure of tensile strength, which is independent of mean fibre diameter and average thickness of staple.	43N/ktex
Style	A code that identifies a particular style within a type group.	Best Topmakers
Tdrfault	A code identifying the presence and type of subjectively assessed wool strength fault.	W1
Vm1	This is the percentage by weight of burr in the core sample of a lot.	0.1
Vm2	This is the percentage by weight of seed and shive in the core sample of a lot.	0.8
Vm3	This is the percentage by weight of hardheads in the core sample of a lot.	0.1
Vmb	This is the vegetable matter base. It consists of burr, grass seeds, thistles, hardheads, straw, chaff and small pieces of stick and bark. It is expressed as a percentage of the weight of the greasy core sample, where: vmb = vm1+ vm2 + vm3	1.0
Woolbase	The oven dry weight of wool free fibre from all impurities. It is expressed as a percentage of the weight of the greasy core sample of a lot.	18.7
Wsa	A unique code identifying the wool statistical area in which the wool was produced.	T03
Yld	This is the measured yield for a lot.	77.4%

Only fleece wool, both Merino and Crossbred, were selected for further analysis thereby excluding the data for skirtings and cardings. Fleece wool was selected as it was the most representative line of wool from which to determine overall wool quality. Crossbred fleeces were included in the analysis as these include the finer comeback wool of which there is a significant percentage in Tasmania, due to the previous Polwarth dominance of the flock.

The fleece wool was then sorted into different categories. Fleece wool coarser than 16μm but less than 19μm was divided into 0.2μm intervals; wools between 19μm and less than 25μm were divided into 0.5μm intervals and wools between 25μm and 30μm were divided into 1μm intervals (Table 3.2).

The total production of fleece wool in kilograms for each of the above categories was calculated by obtaining the sum of the greasy weight using the 'lot_gross' fields (Table 3.1). This was then recorded in a summary table for each individual WSA.

Table 3.2: Mean Fibre Diameter Categories

0.2 μm interval	**0.5 μm interval**	**1 μm interval**
x < 16	19 ≤ x < 19.5	25 ≤ x < 26
16 ≤ x < 16.19	19.5 ≤ x < 20	26 ≤ x < 27
16.2 ≤ x < 16.39	20 ≤ x < 20.5	27 ≤ x < 28
16.4 ≤ x < 16.59	20.5 ≤ x < 21	28 ≤ x < 29
16.6 ≤ x < 16.79	21 ≤ x < 21.5	29 ≤ x < 30
16.8 ≤ x < 16.99	21.5 ≤ x < 22	x ≥ 30
17 ≤ x < 17.19	22 ≤ x < 22.5	
17.2 ≤ x < 17.39	22.5 ≤ x < 23	
17.4 ≤ x < 17.59	23 ≤ x < 23.5	
17.6 ≤ x < 17.79	23.5 ≤ x < 24	
17.8 ≤ x < 17.99	24 ≤ x < 24.5	
18 ≤ x < 18.19	24.5 ≤ x < 25	
18.2 ≤ x < 18.39		
18.4 ≤ x < 18.59		
18.6 ≤ x < 18.79		
18.8 ≤ x < 18.99		

The fibre diameter categories were decided in conjunction with industry partners (*pers. comm.* A.Bailey, A.Downie, M.Best, R.Wallace) to align with the objectives of this study. It is acknowledged that the nomenclature describing fibre diameter categorisations can vary between studies. For the purpose of this analysis the descriptors shown in Table 3.3 were used.

Table 3.3: Descriptors used for Fibre Diameter Categories

Descriptor	Mean Fibre Diameter Category
Superfine wool	< 18.5 μm
Fine wool	18.5 μm ≤ x < 20 μm
Medium wool	20 μm ≤ x < 22 μm
Strong wool	22 μm ≤ x < 24 μm
Superstrong wool	≥24 μm

Total fleece wool production for different yields was selected by specific yields using the "AutoFilter" command on the 'yld' field (Table 3.1). Firstly, fleece wool was selected from the database and then filtered into the fibre diameter categories (Table 3.3). Wool was then divided into yield categories (Table 3.4). The total production of fleece wool in kilograms for the combined specifications was calculated by obtaining the sum of the greasy wool using the 'lot_gross' field. This was then recorded in a summary table for each WSA.

Table 3.4: Yield and Fibre Diameter sort selections

Mean Fibre Diameter Categories
x < 18.5 μm
18.5 μm ≤ x < 20 μm
20 μm ≤ x < 22 μm
22 μm ≤ x < 24 μm
x ≥ 24 μm

Yield Categories
x < 50 %
50 % ≤ x < 55 %
55 % ≤ x < 60 %
60 % ≤ x < 65 %
65 % ≤ x < 70 %
70 % ≤ x < 75 %
75 % ≤ x < 80 %
80 % ≤ x < 85 %
85 % ≤ x < 90%
90 % ≤ x < 95 %
95 % ≤ x < 100 %

The 'style' field was split into eight main specification categories. As style is more important in classifying wool as it becomes finer, only two fibre diameter categories were used (Table 3.5).

Table 3.5: Style and Micron sort selections

Mean Fibre Diameter Categories
x < 18.5 µm
x ≥ 18.5 µm

Style Categories
Choice
Superior
Spinners
Best Topmakers
Good Topmakers
Average Topmakers
Inferior Topmakers
Other

Wool sorted into the 'other' category was from uncommon lines that did not fit into the seven main Australian Wool Corporation (AWC) style categories. The total production of fleece wool in kilograms for each of these categories was calculated by obtaining the sum of the greasy wool using the 'lot_gross' field.

Table 3.6: Colour Fault Categories

Fault Code	Description
H1	Light unscourable colour
H2	Medium unscourable colour
H3	Heavy unscourable colour

Colour fault was categorised into the three subjective colour specifications, as sufficient objective measurements were not available in sufficient seasons to allow a conclusive analysis (Table 3.6). Firstly, fleece wool was divided into mean fibre diameter categories (Table 3.3) and secondly in colour categories. The total production for each category was then determined and tabulated (Table 3.7).

Table 3.7: Colour Fault and Mean Fibre Diameter Sort Selections

Mean Fibre Diameter Categories
x < 18.5 µm
18.5 µm ≤ x < 20 µm
20 µm ≤ x < 22 µm
22 µm ≤ x < 24 µm
x ≥ 24 µm

Colour Fault Categories
H1
H2
H3

Selections were then made for subjectively assessed strength faults amongst the fleece wool, as sufficient objective measurements were not available for a conclusive analysis. The sort selections are shown in

Table 3.9. Again, mean fibre diameter was divided into the specified categories (Table 3.3). Each of these five fibre diameter divisions were individually selected and then total fleece wool production for each of the strength classifications (Table 3.8) was determined and tabulated.

Table 3.8: Strength classifications

Fault Code	Description	
W1	Part Tender	25-30 N/Ktex
W2	Tender	18-24 N/Ktex
V	Rotten	≤ 17 N/Ktex

Table 3.9: Strength and Mean Fibre Diameter Sort Selections

Mean Fibre Diameter Categories
x < 18.5 μm
18.5 μm ≤ x < 20 μm
20 μm ≤ x < 22 μm
22 μm ≤ x < 24 μm
x ≥ 24 μm

Tender Fault Categories
W1
W2
V

Each vegetable matter (vm) field (vm1, vm2 and vm3) was sorted into the five fibre diameter categories. Each vm type was divided into three levels of contamination and total production of fleece wool for each selected category of vm fault (Table 3.10) was obtained.

Table 3.10: VM Fault and Mean Fibre Diameter Sort

Mean Fibre Diameter Categories
x < 18.5 μm
18.5 μm ≤ x < 20 μm
20 μm ≤ x < 22 μm
22 μm ≤ x < 24 μm
x ≥ 24 μm

VM Categories
0 < x ≤ 1.1%
1.1 ≤ x < 3%
x ≥ 3%

Data was then sorted into 10 mm staple length categories for each of the five different mean fibre diameter categories. The total production for each of the length classifications within the micron categories was determined. However a conclusive analysis could not be made due to the lack of objective measurements for length fault for all seasons. There were no recorded subjective measurements for staple length that could be substituted.

The results from each of these sort options (fibre diameter, yield, style, colour, strength, vm and length) were then calculated as a percentage of the total fleece production. This was determined by the sum of each sort category divided by the total fleece production.

All the above selections for each wool characteristic were written into Microsoft® Excel Macros, which were then run across all WSA and seasons. Summary tables were made from this data for each season and each WSA. Means for the combined six seasons were also calculated for each WSA.

3.2 General Characterisation of New South Wales and Victorian Wool Production

WSA within NSW and Victoria were selected (*pers. comm.* M.Best, R.Wallace, G.Lennehan and R.Lance) by their reputation of producing similar wool to Tasmania. Five WSA in NSW (N3, N5, N17, N23 and N24) and six in Victoria (V21, V22, V26, V29, V31 and V34) were selected for a comparative analysis with Tasmania.

In order to determine the characteristics of these competing WSA wool clip data from the 1991/92 through to 1996/97 seasons were analysed. This data was purchased from Wool International with the same 32 fields used for this analysis as for the previous analysis of Tasmanian wool (Table 3.1).

The Microsoft® Excel Macros developed to analyse Tasmania's WSA (Section 3.1) were run on each WSA for NSW and Victoria for each season to provide summary tables and means across all six seasons and 11 WSA. Sufficient data was not found in V31 so this WSA was removed from further analyses.

3.3 The Influence of Wool Characteristics on Raw Wool Price

Tasmania, NSW and Victoria's fleece wool data were divided into three different micron categories for this analysis:

Fine Wool	$18.5 \leq x < 20$
Medium Wool	$20 \leq x < 22$
Strong Wool	$22 \leq x < 24$

It should be noted that these differ to the micron descriptors used in the previous analyses, as the superfine and superstrong categories were not included due to low volume of wool in the NSW and Victorian WSA.

Each season of wool was divided into fine, medium and strong wool and saved as individual CSV (comma delimited) files in Microsoft® Excel. The CSV files were loaded individually into a Multiple Linear Regression (MLR) Programme, written by Dr Brian Horton, Tasmanian Department of Primary Industries, Water and Environment, and multiple regression analyses were carried out. The level of significance used was 5% unless otherwise stated. All three micron categories for each season were analysed individually.

For the MLR to be carried out, data fields that influenced wool price were identified. These fields were encoded:

C - non-numeric values considered in the cost analysis

D - base value to which all other values are compared

N - numeric values considered in the cost analysis

The largest subfield, within each field that was encoded with a C, was selected. It was to this selected subfield that all other subfields were compared. For example in the colour field there were 4 subfields, H0, H1, H2 and H3. The H0 subfield had the largest number of fleeces within it and therefore it was the selected subfield and all other subfields, H1, H2 and H3, were compared to H0. The selected subfields were the same for all Tasmanian analysis and are listed in Table 3.11 and Table 3.12.

Table 3.11: First Multiple Linear Regression (MLR) Analysis

Code	C	C	C	C	C	C	N
Field	wsa	sellcen	*saleno*	*Colour*	*tender*	*style*	yld
Selected subfield	T05	Lau	yr02	H0	W0	DBest	
Associated field from Table 3.1	Wsa	Sellcen	Series	Colfault	Tdrfault	Style	Yld

Code	N	D	C	C	N	N	N
Field	micr	cln c/kg	mof	Clipprep	vm1	vm2	vm3
Selected subfield			1	0			
Associated field from Table 3.1	Micr	Lastbidcln	Mof	Clipprep	Vm1	Vm2	Vm3

Table 3.12: Second MLR Analysis

Code	C	C	C	C	C	N	N	D
Field	wsa	sellcen	*saleno*	*Colour*	*style*	yld	micr	cln c/kg
Selected subfield	T05	Lau	yr02	H0	Dbest			
Associated field from Table 3.1	Wsa	Sellcen	Series	Colfault	Style	Yld	Micr	Lastbid cln

Code	C	N	N	N	N	C	N	N
Field	clipprep	vm1	vm2	vm3	pobmid	*len c*	stapln-cv	*lowstr*
Selected subfield	0					0		
Associated field from Table 3.1	Clipprep	Vm1	Vm2	Vm3	Pobmid	Staplen	Staplen_ cv	Stapstr

The fields in italics in Table 3.11 and Table 3.12 are the fields in which the format was altered so that the MLR could be performed. The way in which these fields were altered is shown in Table 3.13. For example in the colour field, subfields without a fault were blank and to allow MLR to be performed they were labelled H0.

Two separate MLR's were undertaken on each season. This was so that objective and subjective measurements could be analysed separately. Table 3.11 lists the fields included in the subjective assessment. The influence of price on these fields was determined by a MLR analysis. A second MLR for objective measurements was carried out using fields in Table 3.12. However, due to the lack of objective measurements within the wool data no analysis could be completed.

Table 3.13: Fields in which the format has been altered

Field	Alteration
Saleno	A 2 digit number indicating the year in which the sale occur was placed in front of the sale number
Colour	Colour fault present was indicated by H1, H2, H3 and if there was no colour fault present this was indicated by H0
Tender	Tender fault was indicated by W1, W2, with W4 representing V and W0 representing fleece wool without tenderness present
Style	All styles were distributed into 12 basic styles
Lenc	Staple length was placed into 10 cm lots by rounding down to the nearest 10 cm
Lowstr	Wool above 35 N/kTex was sound and for every unit the strength was below 35 N/kTex lowstr received one unit

Upon the completion of the individual Tasmanian analysis, the same analyses were performed on the combined NSW, Victorian and Tasmanian data. The statistical significance was recorded.

3.4 Analysis of Cost of wool faults to Tasmania, New South Wales and Victoria

To determine the discount in c/kg for faults across all fleece wool a number of calculations were made. Colour and strength were the only wool characteristics, which had a sufficient amount of fault to determine a price discount across all fleece wool for every season for each state.

For Tasmania, NSW and Victoria all fleece wool was split into the season in which it was produced. The total amount of fleece wool with fault for each of the fault categories (Colour: H1, H2, H3; Strength: W1, W2, W3) was determined. The amount of fault calculated for each category was then divided by the total amount of fleece produced in that season to determine the percent of fault within the fleece wool (this was calculated in Section 4.1 for Tasmanian wool and Section 4.2 for NSW and Victorian wool).

To determine the cost of each fault category for every kilogram of fleece wool produced within each state, the discount coefficients (these were determined by the MLR analyses in Section 3.3) were multiplied by the percent of fault within fleece wool (calculated above). This provided a discount in c/kg for each fault category within each season for Tasmania, NSW and Victoria. Allowing the overall cost to each state for faults to be determined (An example of these calculations are shown in Appendix 1).

Chapter Four: Results

4.1 Characterisation of the Tasmanian Clip for the 1991/92 to 1996/97 seasons

4.1.1 Introduction

Aim: To determine the quality of Tasmanian wool and how variation in quality occurs throughout the state's wool growing regions and between seasons.

Fibre diameter, style, yield, strength, and vegetable matter content are the major traits used to specify wool and hence determine wool quality. The combination of these properties determines the price received for wool and by quantifying each of these characteristics within a wool clip it is possible to predict how the wool will perform during processing and estimate its value (Ive *et al.*, 1988). The differences between wool characteristics, both general characterisation and faults within each selected wool statistical area, will be discussed in this chapter with respect to the Tasmanian wool clip for the 1991/92 to 1996/97 seasons.

4.1.2 General Tasmanian Production

Tasmania produces between 2-3% of Australia's wool. Production has varied from a low of 17.02 million kg in 1995/96 to a high of 19.74 million kg in 1996/97 (Figure 4.1).

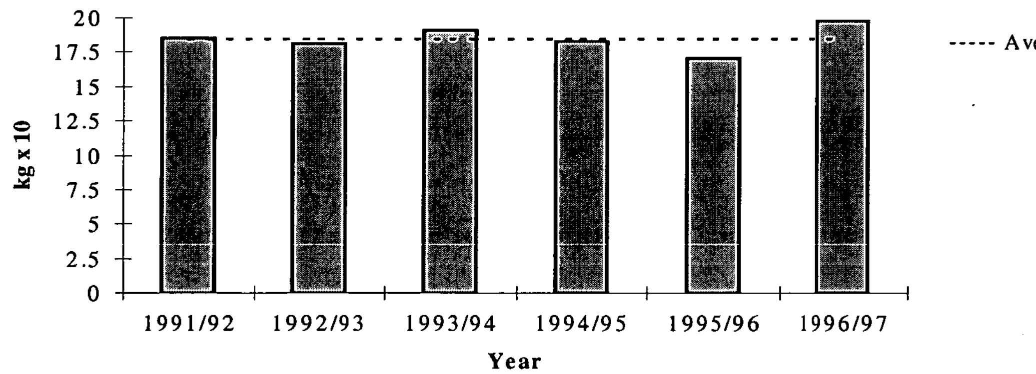


Figure 4.1: Annual fleece production for Tasmania

Wool production within Tasmania is divided into ten WSA. The average proportion of wool produced in each WSA for the season's 1991/92 to 1996/97 is shown in Figure 4.2. Total production, during this period, varied considerably across the state, with T08 producing 515 kg to T04 producing 16.59 million kg. From the ten WSA the five highest producing areas (T03, T04, T05, T06 and T10) were selected for further analysis. These areas produce approximately 90% of Tasmania's wool.

T10 produces only slightly more wool than T01, which is the Hobart area, however T10 was included in the analysis instead of T01. As a result, T01 is unrepresentative as it receives most of its wool as odd lots from throughout Tasmania, brought to the brokers' Hobart stores (Section 3.1).

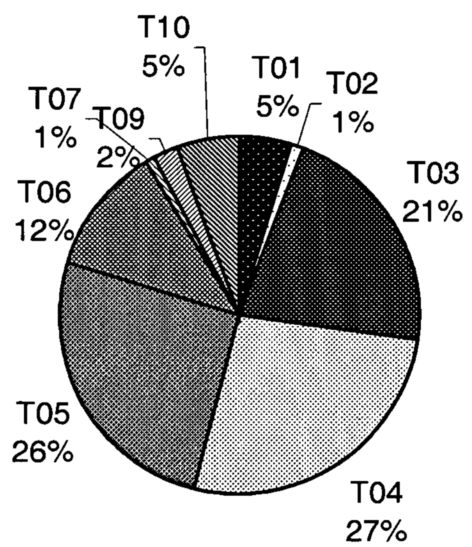


Figure 4.2: Mean proportion of total Tasmanian wool production for each WSA for the period 1991/92 to 1996/97.

The average production for wool varies between WSA with T03, T04 and T05 producing the majority of Tasmania's wool (Figure 4.3).

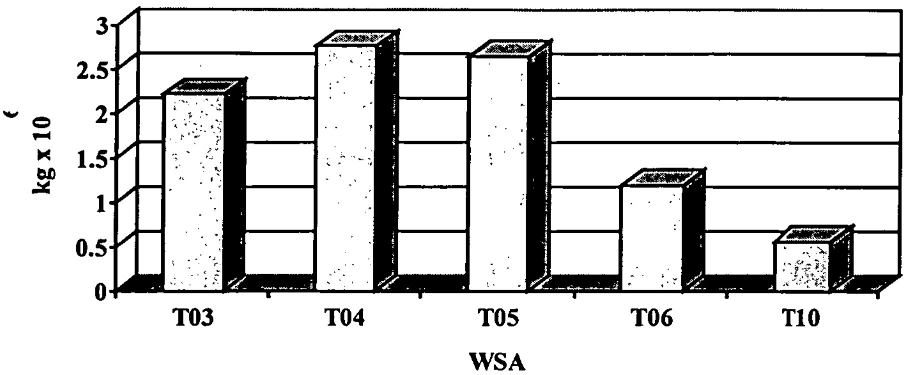


Figure 4.3: Average wool production from 1991/92 to 1996/97 for five WSA, T03, T04, T05, T06 and T10.

4.1.3 Fibre Diameter

The fibre diameter of Tasmania's wool varied both between WSA and within WSA. The majority of wool is in the range 18.5μm to 24μm (Table 4.1).

Table 4.1: Percentage (%) of each fibre diameter category in selected Tasmanian WSA (average of 1991/92 to 1996/97 seasons).

WSA	Fibre Diameter category				
	Superfine <18.5	Fine 18.5-20	Medium 20-22	Strong 22-24	Superstrong >24
T03	8	17	46	23	6
T04	5	12	34	33	16
T05	6	15	39	31	9
T06	9	25	44	19	3
T10	1	3	26	52	18

T06 had the largest proportion of fine and superfine wool (< 20μm) in Tasmania followed by T03. Flinders Island, T10, had the largest proportion of strong wool with over 70% of the fleece being coarser than 22μm.

T03 is the third largest wool producing area within Tasmania and includes the major population centres of Scottsdale, St Helens, St Marys, Campbell Town and Ross (Appendix 2). The majority of the region's fleece wool has a mean fibre diameter less than 22 μm. The average annual production for T03 across the six seasons was 2.21 million kg of wool. This varied between the 1.87 million kg of fleece produced in 1992/93 and the 2.45 million kg produced in 1996/97 (Figure 4.4).

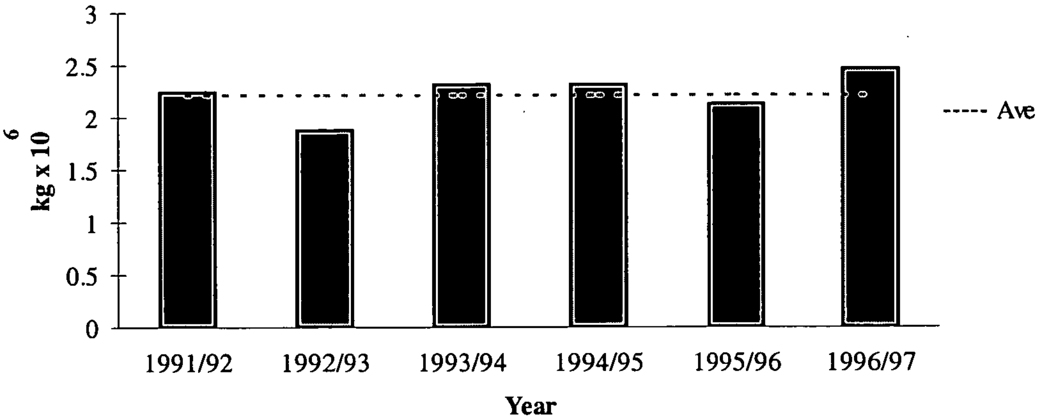


Figure 4.4: Annual fleece production for T03

T04 is the largest wool producing WSA in Tasmania. It includes the major population centres of Launceston, George Town, Longford, Westbury and Deloraine. Wool production varied between seasons with only 2.05 million kg of fleece wool produced in 1991/92 but 3.28 million kg produced in 1996/97. The fleece production across the six seasons averaged 2.76 million kg (Figure 4.5). The majority of wool produced was in the medium to strong categories i.e. 20-24μm. However the clip has been getting progressively finer throughout the period analysed.

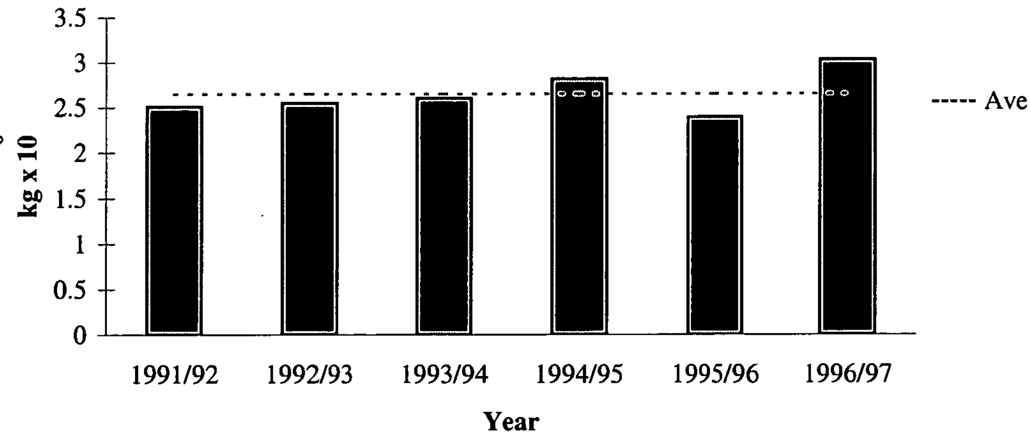


Figure 4.5: Annual fleece production for T04

T05 is the second largest wool producing area within Tasmania, and contains the population centres of Oatlands, Bothwell, Hamilton and Tarraleah. The region's wool can be categorised as medium to strong (20-24μm). The fleece production across the six seasons averaged 2.64 million kg. This varied between seasons, with 1995/96 producing 2.39 million kg, while 1996/97 produced 3.02 million kg (Figure 4.6).

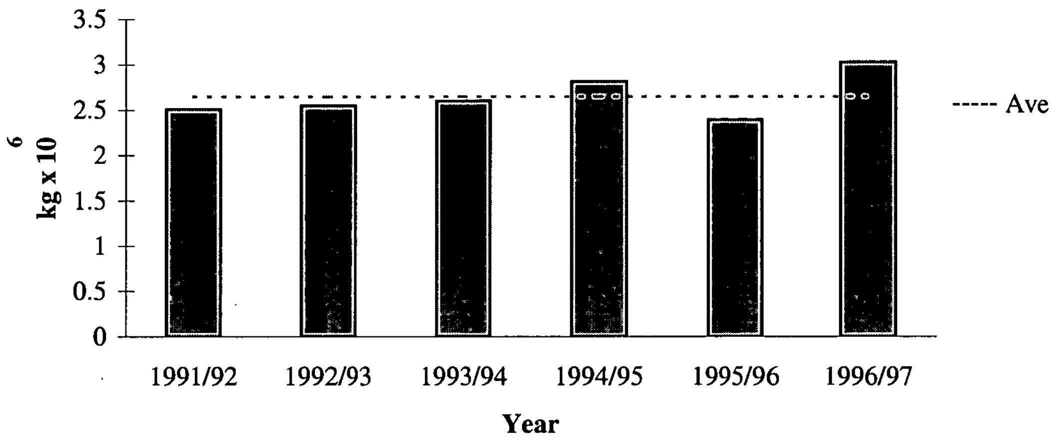


Figure 4.6: Annual fleece production for T05

T06 produces the largest proportion of fine wool within Tasmania and includes the major population centres of Bicheno, Swansea, Orford, Port Arthur, Richmond and Kempton. Production varied between seasons with only 0.97 million kg in 1995/96 and 1.43 million kg in 1996/97 (Figure 4.7).

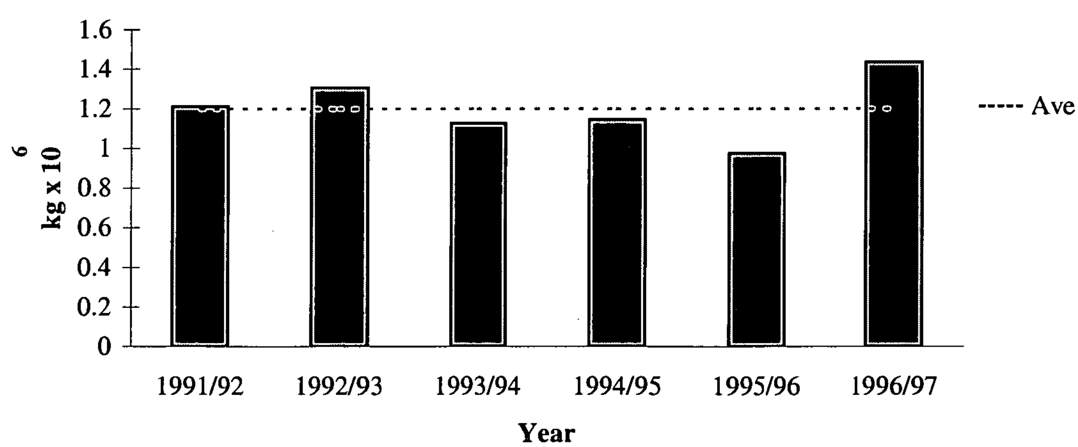


Figure 4.7: Annual fleece production for T06

Flinders Island, T10, had the lowest production of the five selected WSA. Annual production has varied over the six seasons with the largest being 0.62 million kg in 1991/92 and the lowest, 0.59 million kg in 1996/97 (Figure 4.8).

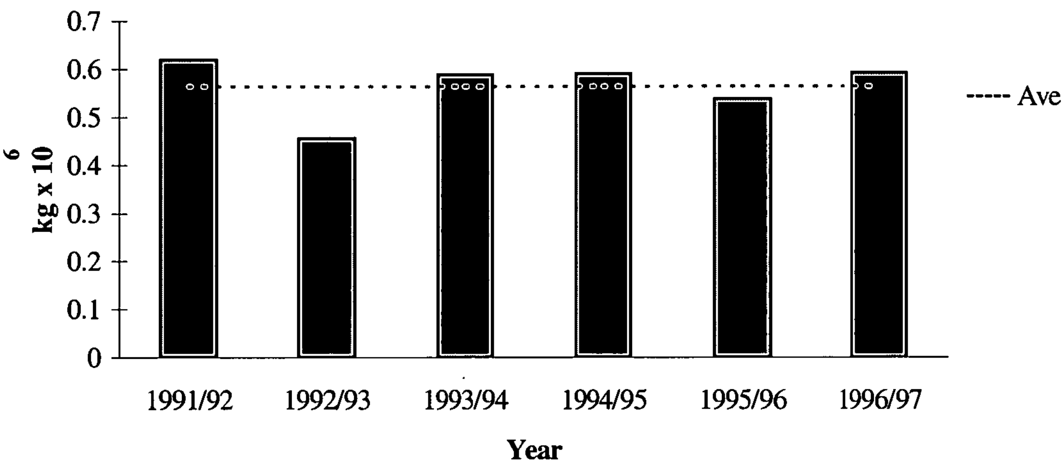


Figure 4.8: Annual fleece production for T10

Flinders Island produces a larger proportion of medium to strong wool than fine wool. The bulk of the wool is in the 20 to 24 μm micron range. The wool clip has progressively become finer, with the 1996/97 season having the largest proportion of wool below 20 μm.

4.1.4 Yield

Yield determines the amount of usable wool fibre obtained from greasy wool after scouring.

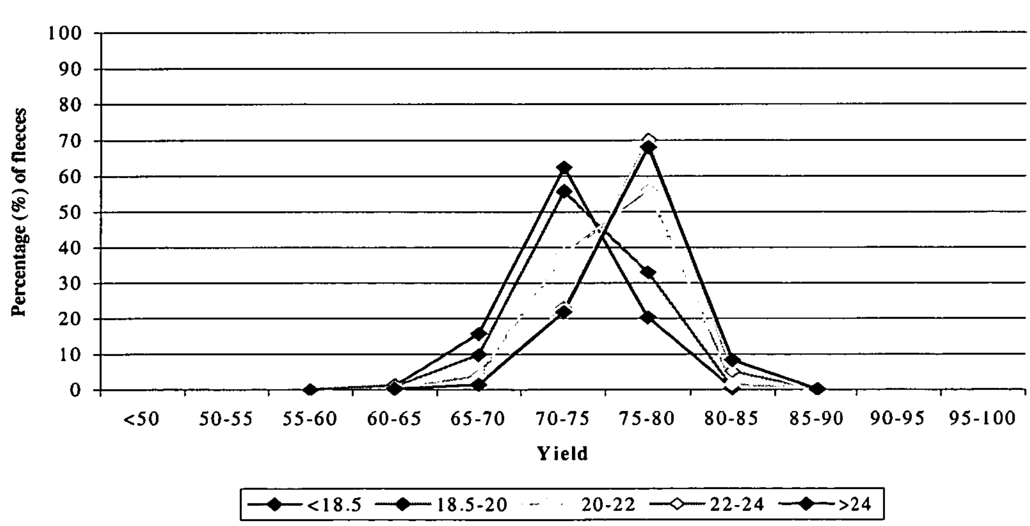


Figure 4.9: Percentage (%) of fleeces in each yield category for different fibre diameter groups.

Yield varied little between the seasons or WSA. The greatest variation was between fibre diameter groups. Hence to obtain a clear indication of the way in which yield differs, the WSA were combined and the average yield was taken across seasons. This analysis showed wools below 20μm had yields approximately 5-10% lower than wools coarser than 20μm (Figure 4.9).

4.1.5 Style

The different styles were found in similar proportions across each WSA so all WSA were combined to determine the common styles.

Table 4.2: Percentage (%) of fleeces, ≤18.5 μm, fitting into the seven main AWC style grades in each season.

STYLE	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Choice	0.2	0.3	0.4	0.1	0.2	0.3
Superior	0.3	0.4	0.5	0.2	0.5	0.7
Spinners	3.1	4.8	6.4	2.8	2.2	4.0
Best Topmaker	37.9	37.2	42.4	39.8	34.4	39.4
Good Topmaker	51.7	53.3	45.2	51.1	58.5	48.2
Average Topmaker	3.7	1.3	2.6	3.7	3.1	3.4
Inferior Topmaker	-	-	-	-	-	-
Other	3.1	2.7	2.5	2.3	1.1	4.0

All wool had on average 50% of production in the good topmakers category and an average of 35% wool in the best topmakers category (Table 4.2). There was no wool in the choice or inferior category and only a small percent the superior, spinners and average topmakers categories (Table 4.3).

Table 4.3: Percentage (%) of fleeces, > 18.5 μm, fitting into the seven main AWC style grades.

STYLE	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97
Choice	-	-	-	-	-	-
Superior	0.1	0.2	0.2	0.1	-	-
Spinners	1.2	1.4	2.1	0.7	1.1	1.9
Best Topmaker	23.7	34.1	37.4	33.2	37.5	46.8
Good Topmaker	58.2	53.5	49.6	55.5	53.4	45.0
Average Topmaker	8.3	5.4	4.1	5.2	3.3	2.4
Inferior Topmaker	-	-	-	-	-	-
Other	8.5	5.4	6.6	5.3	4.7	3.9

4.1.6 Colour

Colour faults were present in low amounts across most seasons and WSA. Generally, Tasmania did not have a problem with heavy (H3) colour faults. Heavy (H3) colour fault occurred at low levels and has only once been above 0.2% of fleece wool (1996, T06 levels were 0.56%).

Table 4.4: Percentage (%) of fleece wool with subjectively assessed medium (H2) colour fault present.

Colour Fault	WSA					
	T03	T04	T05	T06	T10	Average
1991/92	0.6	1.8	0.9	0.6	0.3	**0.8**
1992/93	1.5	2.4	1.4	1.4	0.4	**1.4**
1993/94	0.5	2.4	0.3	0.2	0.5	**0.8**
1994/95	0.4	2.1	0.4	0.2	0.1	**0.6**
1995/96	0.7	3.6	0.3	0.7	0.9	**1.2**
1996/97	1.8	4.2	3.3	2.7	2.1	**2.8**
Average	**0.9**	**2.8**	**1.1**	**1.0**	**0.7**	**1.3**

Medium (H2) colour faults were present in limited numbers, except in T04 (Table 4.4). Levels remained below 4.2% of fleeces over the six seasons in all WSA.

Table 4.5: Percentage (%) of fleece wool with subjectively assessed light (H1) colour fault present.

Colour Fault	WSA					
	T03	T04	T05	T06	T10	Average
1991/92	4.6	11.1	5.7	4.1	3.6	**5.8**
1992/93	6.5	10.6	7.7	5.1	4.0	**6.8**
1993/94	4.4	12.5	4.0	3.5	3.0	**5.5**
1994/95	2.2	5.8	3.7	2.2	2.5	**3.3**
1995/96	5.3	12.6	6.0	6.2	5.6	**7.1**
1996/97	10.7	18.1	10.7	13.7	8.7	**12.4**
Average	**5.6**	**11.8**	**6.3**	**5.8**	**4.6**	**6.8**

Light colour (H1) levels varied across seasons and WSA. Levels of light (H1) colour fault have not exceeded 14% of the fleece wool except in the case of the 1996/97 season in T04 (Table 4.5).

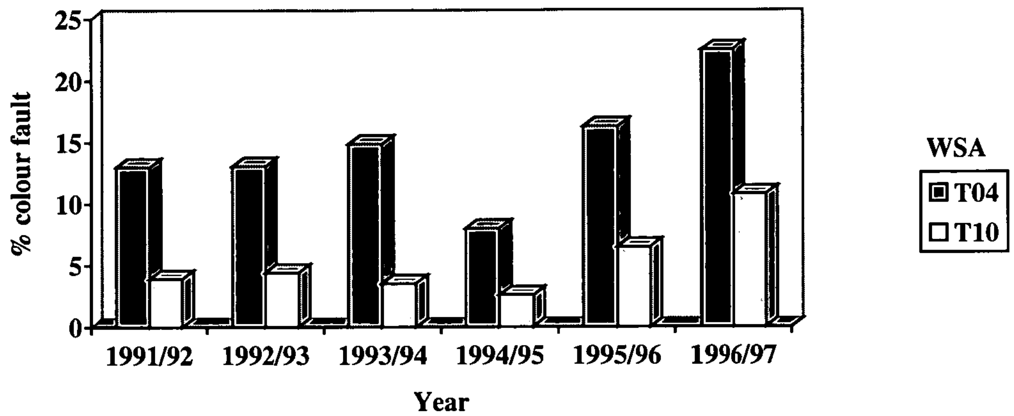


Figure 4.10: Differences in colour faults between T04 and T10 across seasons.

Total colour fault varied between WSA. T04 had the highest annual percent of colour fault and T10 the lowest amongst the WSA analysed (Figure 4.10).

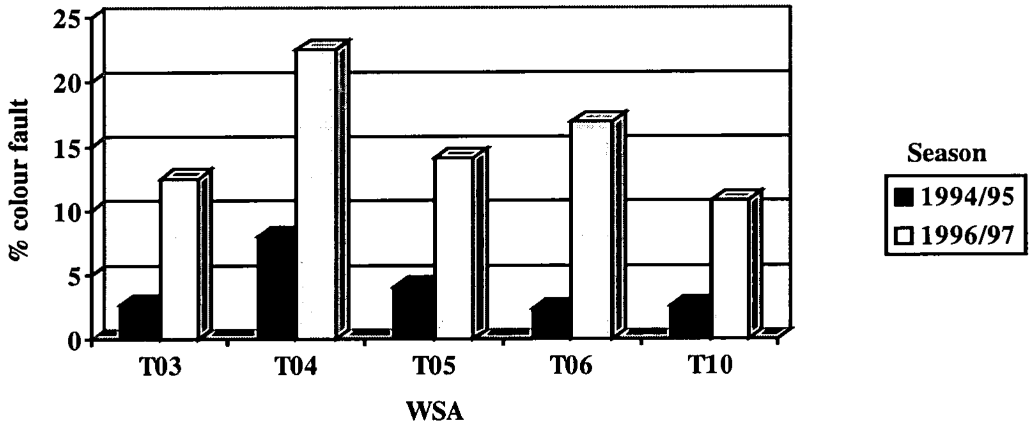


Figure 4.11: Differences in colour faults across WSA between the 1994/95 and 1996/97 seasons.

The 1994/95 season had the lowest incidence of colour fault and the 1996/97 season the highest (Figure 4.11). The total percentage of all colour faults in fleece wool is shown in Table 4.6 for WSA in each season. Colour fault levels varied across the seasons.

Table 4.6: Percentage (%) of fleece wool with subjectively assessed colour fault present.

Colour Fault	WSA					
	T03	T04	T05	T06	T10	Average
1991/92	5.2	13.0	6.7	4.7	3.9	**6.7**
1992/93	8.1	13.1	9.2	6.5	4.5	**8.3**
1993/94	4.9	14.9	4.3	3.7	3.5	**6.3**
1994/95	2.7	8.0	4.1	2.4	2.6	**4.0**
1995/96	6.0	16.3	6.3	7.0	6.5	**8.4**
1996/97	12.5	22.4	14.2	16.9	10.7	**15.3**
Average	**6.6**	**14.6**	**7.5**	**6.9**	**5.3**	**8.2**

4.1.7 Strength

Strength of fleece wool varied across the six seasons. Strength levels also differ between WSA. Rotten wool (V) occurs at very low levels and has never been present in greater than 1.4% of fleeces.

Table 4.7: Percentage (%) of fleece wool with subjectively assessed tender wool (W2).

Tender Fault	WSA					
	T03	T04	T05	T06	T10	Average
1991/92	10.6	11.1	7.8	6.6	6.2	**8.5**
1992/93	6.2	5.6	3.6	3.6	12.1	**6.2**
1993/94	6.1	9.9	5.7	4.4	12.9	**7.8**
1994/95	5.1	6.8	4.6	4.3	7.5	**5.7**
1995/96	5.6	8.1	4.9	4.6	8.0	**6.2**
1996/97	3.1	4.0	2.2	1.3	5.4	**3.2**
Average	**6.1**	**7.6**	**4.8**	**4.1**	**8.7**	**6.3**

Levels of tender wool (W2) varied across seasons and WSA. T05 and T06 had lower levels of strength fault than T03, T04 and T10 (Table 4.7).

Table 4.8: Percentage (%) of fleece wool with subjectively assessed part-tender wool (W1).

Tender Fault	WSA					
	T03	T04	T05	T06	T10	Average
1991/92	20.9	24.1	17.8	15.8	18.6	**19.4**
1992/93	12.9	16.7	12.5	12.1	21.9	**15.2**
1993/94	14.5	19.6	10.7	14.2	15.5	**14.9**
1994/95	13.7	17.4	10.4	12.6	16.9	**14.2**
1995/96	16.1	15.6	11.0	11.9	12.4	**13.4**
1996/97	9.1	11.0	5.6	5.4	4.4	**7.1**
Average	**14.5**	**17.4**	**11.3**	**12.0**	**15.0**	**14.0**

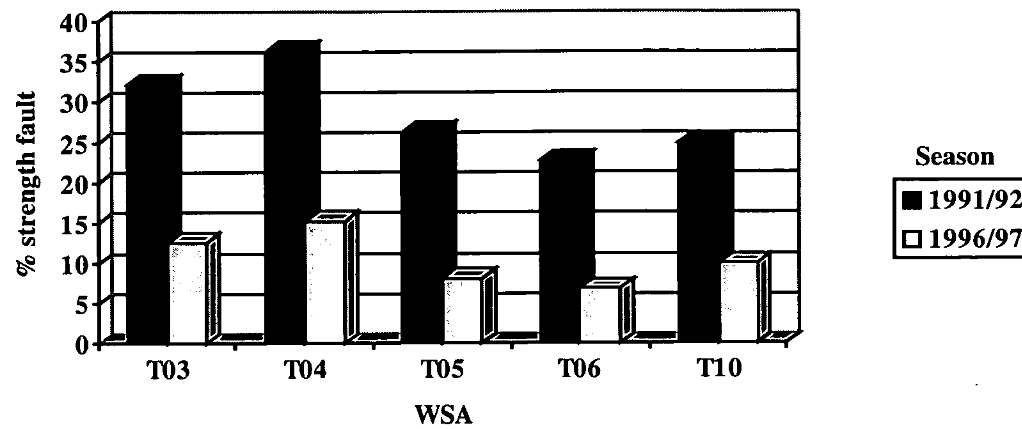


Figure 4.12: Differences in strength faults across WSA and between 1991/92 and 1996/97 seasons.

Part-tender wool (W1) is present in large percentages across the WSA and seasons. Apart from the 1996/97 season, where strength faults were lower than average, part-tender (W1) faults have been present at levels of 10% or greater in fleece wool (Table 4.8) since 1991/92.

Strength was variable across seasons and WSA. The 1996/97 season had the lowest incidence of strength fault and the 1991/92 season the highest except in the case of T10, where the 1992/93 season had the highest incidence (Figure 4.12).

T04 had the highest incidence of strength faults over the last six seasons, with T05 and T06 having the lowest (Figure 4.13).

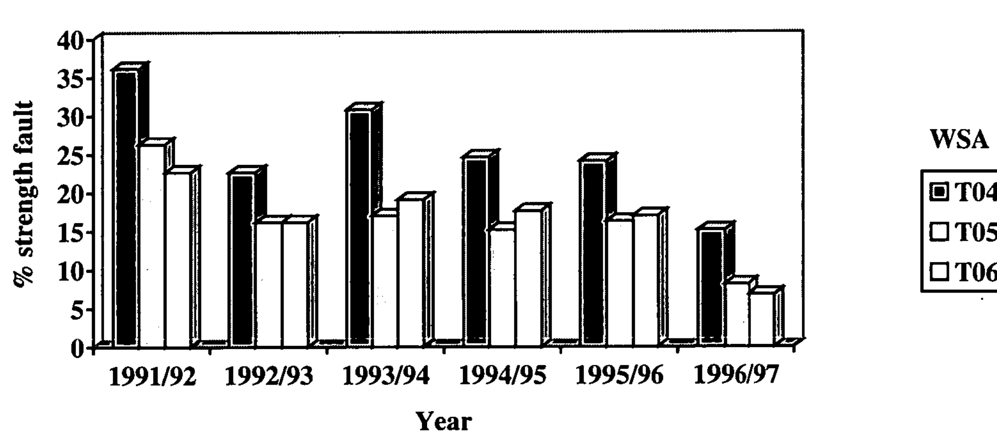


Figure 4.13: Differences in strength faults between T04, T05 and T06 across six seasons.

4.1.8 Vegetable Matter Content

Vegetable matter has three classes; burr (vml), seed (vm2) and hardheads (vm3). These are then graded into three levels:

1). 0-1.1% of vm present in total fleece

2). 1.1-3% of vm present in total fleece

3). Greater than 3% of vm present in total fleece

Burr content (vml) of fleece wool was present at low levels throughout the Tasmanian clip (Table 4.9) both in terms of variation between seasons and between regions.

Table 4.9: Percentage (%) of fleeces with burr (vml) at levels less than 1.1% in each WSA.

Burr	WSA					
Content	T03	T04	T05	T06	T10	Average
1991/92	25.4	28.4	19.9	14.8	17.4	**21.2**
1992/93	15.2	18.5	10.3	10.0	11.6	**13.1**
1993/94	22.0	31.0	16.1	10.0	16.8	**19.2**
1994/95	16.5	20.7	16.4	6.9	9.8	**14.1**
1995/96	17.1	16.7	16.0	12.0	15.8	**15.5**
1996/97	11.2	17.4	10.6	8.8	6.6	**10.9**
Average	**17.9**	**22.1**	**14.9**	**10.4**	**13.0**	**15.7**

Burr (vml) was present in less than 0.2% of fleece wool at levels between 1.1 to 3% over the six seasons. Only once did burr (vml) exceed 0.2% (1992/93, T10 when levels averaged 1.4%).

Seed (vm2) was present in almost all lots. However it was present mainly at levels less than 1.1% (Table 4.10). The 1994/95 season had lowest levels of seed across the six seasons and 1996/97 the highest.

Table 4.10: Percentage (%) of fleeces with seed (vm2) at levels less than 1.1% in each WSA.

Seed	WSA					
Content	T03	T04	T05	T06	T10	Average
1991/92	89	92	97	98	98	**94.8**
1992/93	84	91	98	98	99	**94.0**
1993/94	91	90	93	92	94	**92.0**
1994/95	81	82	87	78	89	**83.4**
1995/96	99	97	97	98	97	**97.6**
1996/97	99	98	99	97	99	**98.4**
Average	**90.5**	**91.7**	**95.2**	**93.5**	**96.0**	**93.4**

The proportion of fleeces with seed (vm2) present at levels of 1.1 to 3% of fleece varied across the last six seasons from 0% (T10, 1994) to 16% (T03, 1992) (Table 4.11).

Table 4.11: Percentage (%) of fleeces with seed (vm2) at levels between 1.1% and 3% in each WSA.

Seed	WSA					
Content	T03	T04	T05	T06	T10	Average
1991/92	10.3	7.3	3.0	1.6	1.4	**4.7**
1992/93	16.1	8.5	1.9	1.3	0.7	**5.7**
1993/94	4.8	5.9	3.6	1.9	1.5	**3.5**
1994/95	1.9	1.8	1.0	0.8	0.0	**1.1**
1995/96	0.8	2.5	0.2	0.9	0.4	**1.0**
1996/97	0.9	2.6	1.2	1.1	0.1	**1.2**
Average	**5.8**	**4.8**	**1.8**	**1.3**	**0.7**	**2.9**

Levels of hardheads (vm3) were low and were not a major fault over the six seasons. Vegetable matter base (vmb), the combination of burr, seed and hardheads, varies considerably between seasons and WSA. Vmb was only investigated in levels greater than 1.1% of the fleece (Table 4.12), as levels below this do not incur a price penalty.

Table 4.12: Percentage (%) of fleeces with vmb levels between 1.1 to 3% in each WSA.

Vmb	WSA					
	T03	T04	T05	T06	T10	Average
1991/92	4.2	2.0	13.1	9.6	2.4	**6.3**
1992/93	2.2	1.9	18.5	11.3	1.3	**7.0**
1993/94	4.5	2.3	6.5	9.7	2.7	**5.1**
1994/95	1.1	1.4	3.0	3.3	0.6	**1.9**
1995/96	0.4	1.2	1.2	3.6	1.1	**1.5**
1996/97	1.3	1.3	1.1	3.7	0.5	**1.6**
Average	**2.3**	**1.7**	**7.2**	**6.9**	**1.4**	**3.9**

T05 had the highest vmb levels over the six seasons and T10 the lowest, however these levels have declined progressively throughout the period of the data set (Figure 4.14). Differences between seasons also occur for all WSA (Figure 4.15) with 1992/93 having the largest amount of vmb between the 1.1-3% level.

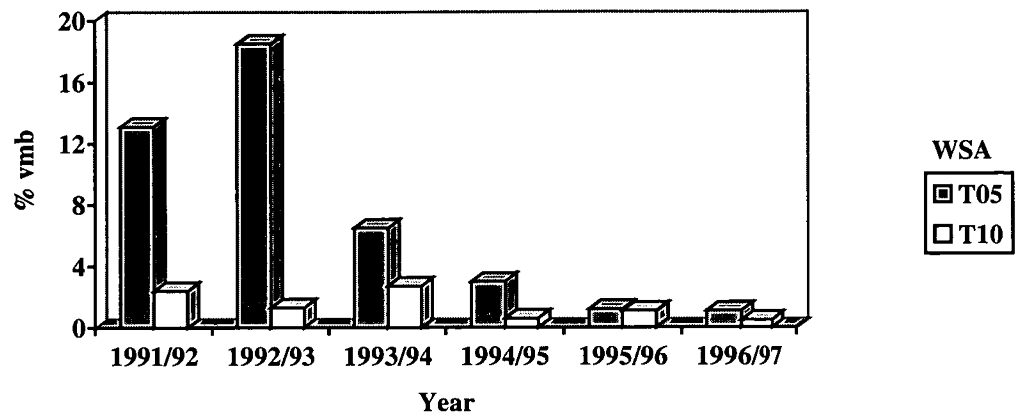


Figure 4.14: Differences in vmb levels, between T05 and T10, across seasons

Vmb, at levels greater than 3% of the fleece, have not been present in greater than 0.3% of fleece lots in any WSA for any of the six seasons.

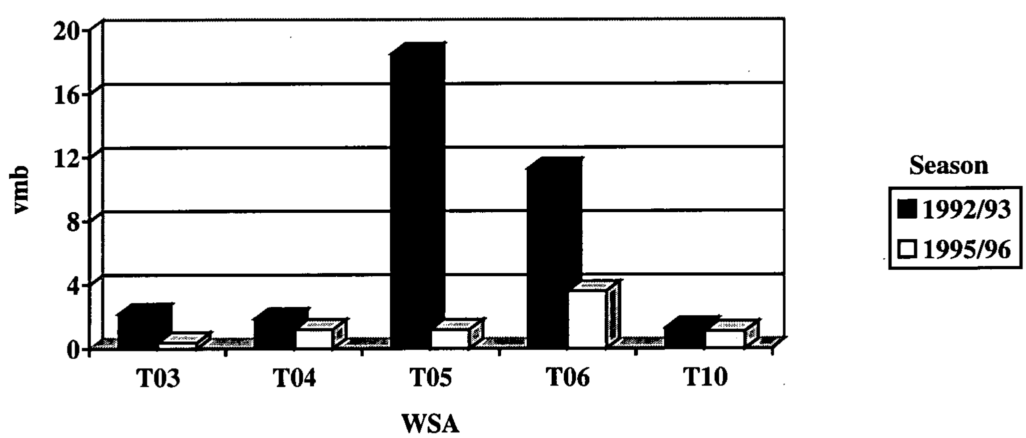


Figure 4.15: Differences in vmb (1.1-3%) levels across WSA, between the 1992/93 and the 1994/95 seasons.

4.2 A Characterisation of the New South Wales and Victorian Clips for the 1991/92 to 1996/97 seasons

4.2.1 Introduction

Aim: To outline the wool quality, of specific WSA in both NSW and Victoria, which produce similar wool to Tasmania. This will allow Tasmanian wool quality to be accurately compared with its competitors. Seasonal conditions are also considered to determine if there are any trends in the influence of season on wool quality.

The general characteristics of the wool produced within NSW and Victoria were identified to allow for comparisons between Tasmanian, NSW and Victorian wool. The proportion of wool in each fibre diameter category across each WSA is shown in Table 4.13, these being averages across the six seasons, 1991/92 to 1996/97.

Table 4.13: Percentage of each fibre diameter category in each NSW and Victorian WSA

WSA	Fibre diameter category				
	Superfine < 18.5	**Fine 18.5-20**	**Medium 20-22**	**Strong 22-24**	**Superstrong> 24**
N03	36	31	17	5	11
N05	9	26	49	13	4
N17	22	23	35	14	7
N23	12	25	39	16	8
N24	4	19	50	21	6
V21	9	22	38	18	14
V22	7	20	43	23	7
V26	7	19	35	19	20
V29	6	18	37	21	18
V34	7	23	48	15	7
Tas Total	***6***	***14***	***38***	***32***	***10***

N03 and N17 produce the largest proportion of superfine wool amongst the NSW and Victorian WSA selected. The majority of wool in all the selected WSA falls between 18.5μm and 22μm. The average wool production for the last six seasons, 1991/92 to 1996/97, for each WSA analysed in NSW and Victoria, is shown in Figure 4.16.

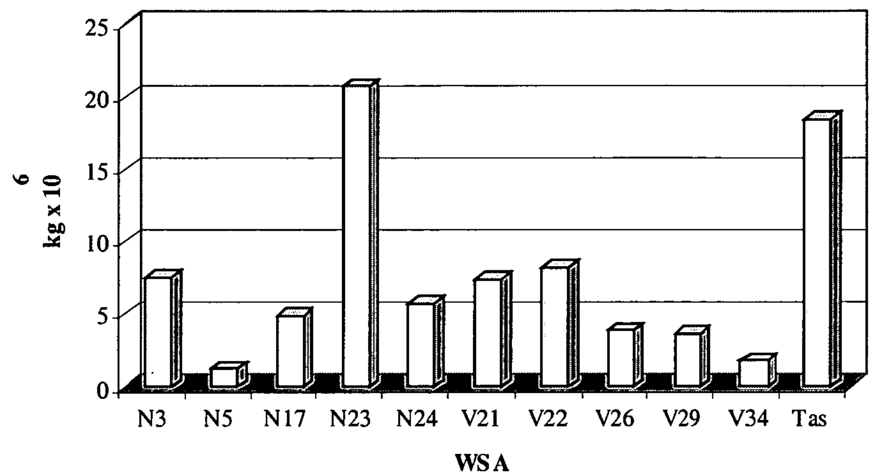


Figure 4.16: Average fleece production, 1991/92 to 1996/97, for selected WSA within NSW and Victoria and total Tasmanian production.

Area N23 (20.73 million kg) had the highest average annual production of the WSA analysed and N5 (1.25 million kg) the smallest, this pattern being consistent for all seasons from 1991/92 to 1996/97.

4.2.2 Yield

Yield had little variation between the seasons analysed or between WSA in NSW and Victoria.

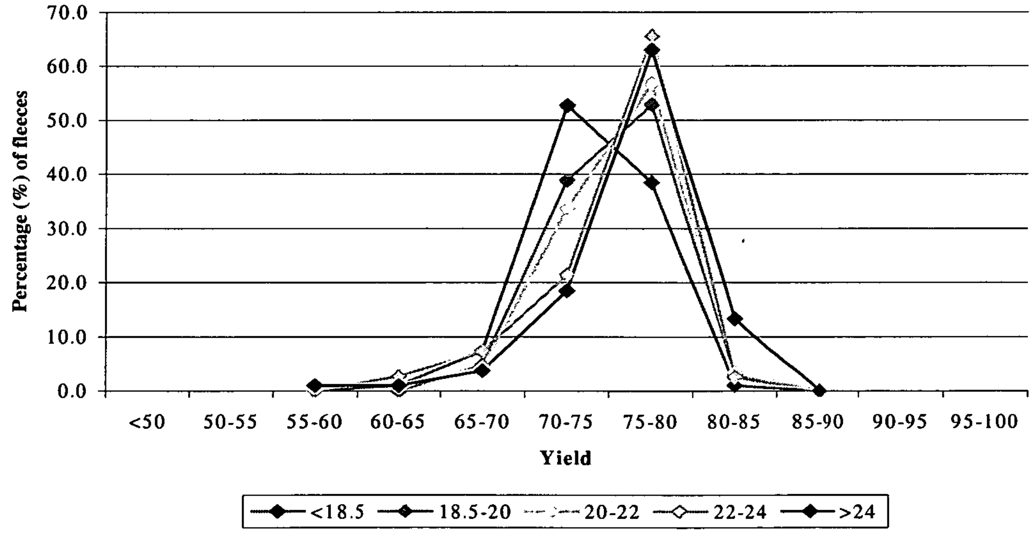


Figure 4.17: Percentage (%) of fleeces in each yield category for different fibre diameter groups in N03.

Fibre diameter had the biggest effect on yield with the coarser wool having a higher yield than fine wool. This can be seen in N03 (Figure 4.17).

4.2.3 Style

The different styles were found in similar proportions across each WSA so all WSA were combined to determine what styles were common.

Table 4.14: Percentage of fleeces within NSW, ≤18.5 μm, assessed as belonging to one of the seven main AWC style grades in each season.

STYLE	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	*Ave Tas*
Choice	-	0.2	0.1	0.2	0.1	0.1	*0.3*
Superior	0.1	0.1	0.1	0.2	0.1	0.2	*0.4*
Spinners	1.4	5.0	2.9	3.2	1.8	5.5	*3.9*
Best Topmaker	44.9	51.7	52.7	44.4	47.0	49.8	*38.5*
Good Topmaker	49.1	39.6	40.6	46.0	48.8	40.9	*51.3*
Average Topmaker	2.5	1.7	1.6	3.7	1.2	1.6	*3.0*
Inferior Topmaker	-	-	-	0.2	-	-	-
Other	2.0	1.7	2.0	2.1	1.0	1.9	*2.6*

The majority of fleeces, around 49%, were in the best topmaker category and about 44% of fleeces in good topmaker. Very small proportions of fleeces were classified into the choice and superior styles. NSW fleeces that were finer than 18.5μm had a greater proportion of fleeces in the top four styles than wools coarser than 18.5 μm (Table 4.14 and Table 4.15).

Table 4.15: Percentage (%) of fleeces within NSW, > 18.5 μm, assessed as belonging to one of the seven main AWC style grades.

STYLE	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	*Ave Tas*
Choice	-	-	-	-	-	-	-
Superior	-	-	-	-	-	-	*0.1*
Spinners	0.5	1.0	0.6	0.9	0.5	3.1	*1.4*
Best Topmaker	48.2	53.7	53.2	48.5	46.1	59.7	*35.5*
Good Topmaker	45.3	41.0	41.8	45.5	48.3	33.3	*52.5*
Average Topmaker	1.7	0.9	1.0	2.2	2.1	1.2	*4.8*
Inferior Topmaker	-	-	-	0.1	-	-	-
Other	4.3	3.4	3.4	2.8	3.0	2.7	*5.7*

Victorian wools coarser than 18.5μm (Table 4.17) had no fleeces classified as choice or superior. A small proportion of wools were classified into the spinners category.

Table 4.16: Percentage (%) of fleeces within Victoria, ≤18.5 μm, assessed as belonging to one of the seven main AWC style grades NSW

STYLE	1991/ 92	1992/ 93	1993/ 94	1994/ 95	1995/ 96	1996/ 97	*Ave Tas*
Choice	0.1	0.1	0.2	0.1	-	-	***0.3***
Superior	-	0.1	0.1	0.1	-	-	***0.4***
Spinners	1.6	1.8	3.9	4.3	1.5	1.8	***3.9***
Best Topmaker	50.7	51.3	59.0	61.4	54.4	50.0	***38.5***
Good Topmaker	43.7	40.2	30.8	29.7	39.8	42.0	***51.3***
Average Topmaker	1.6	2.4	2.5	2.0	2.0	2.6	***3.0***
Inferior Topmaker	-	-	-	-	-	-	-
Other	2.3	4.1	3.5	2.4	2.3	3.6	***2.6***

The best topmaker category had the highest proportion of fleeces in NSW and Victoria. Good topmaker ranged from 24.5% to 40.1% in NSW and 14.6% to 20.7% in Victoria depending on WSA. Average topmaker had 0.2% of fleeces in Victoria and no inferior topmaker were present in any of the six seasons. In NSW average topmaker ranged from 0% in 1991/92 to 1.1% in 1994/95. Only once in the six seasons (1994/95) was any wool present in the inferior topmaker category.

Table 4.17: Percentage of fleeces within Victoria, > 18.5 μm, assessed as belonging to one of the seven main AWC style grades.

STYLE	1991/ 92	1992/ 93	1993/ 94	1994/ 95	1995/ 96	1996/ 97	*Ave Tas*
Choice	-	-	-	-	-	-	-
Superior	-	-	-	-	-	-	***0.1***
Spinners	1.0	1.6	2.8	2.9	1.8	1.7	***1.4***
Best Topmaker	53.8	63.4	63.5	65.0	65.9	63.9	***35.5***
Good Topmaker	39.8	30.7	29.4	27.6	29.0	30.6	***52.5***
Average Topmaker	1.8	1.3	1.2	1.3	1.0	1.1	***4.8***
Inferior Topmaker	-	-	-	-	-	-	-
Other	3.6	3.0	3.1	3.2	2.3	2.7	***5.7***

4.2.4 Colour

Colour fault varied between seasons and WSA. The greatest difference in colour fault occurred in two successive seasons 1993/94 and 1994/95. The 1993/94 season had the highest occurrence of colour fault and 1994/95 had the lowest levels of colour fault in NSW and Victoria (Figure 4.18).

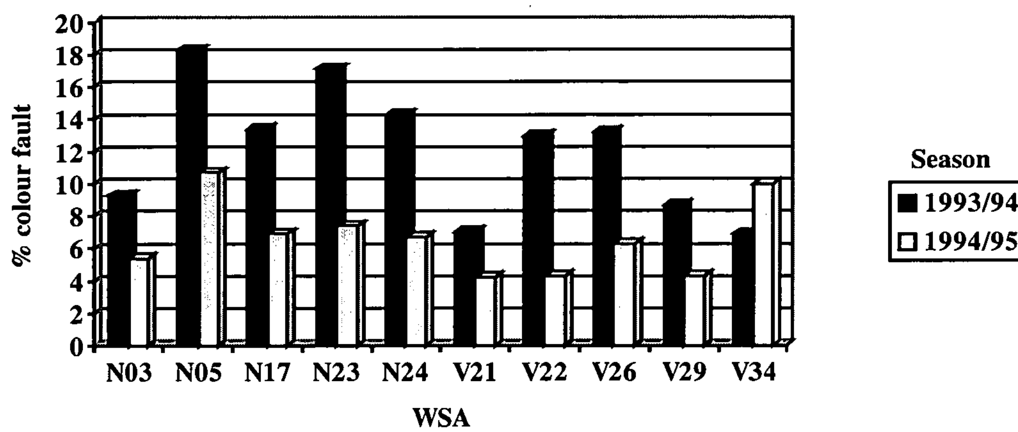


Figure 4.18: Differences in incidence of colour fault between WSA for the 1993/94 and 1994/95 seasons.

Heavy (H3) colour fault was present in levels less than 0.5% of fleeces, across the six seasons, in NSW and Victorian wool. The levels of medium (H2) colour fault have been less than 2% of fleeces in NSW and 2.3% in Victoria for the six seasons. The level of light (H1) colour faults has fluctuated (Table 4.18) with N05 having the highest and V29 the lowest levels of fault within NSW and Victoria over the seasons analysed (Figure 4.19).

Table 4.18: Percentage (%) of fleece wool with subjectively assessed light (H1) colour fault present.

Colour	WSA									
Fault	**N03**	**N05**	**N17**	**N23**	**N24**	**V21**	**V22**	**V26**	**V29**	**V34**	***TAS***
1991/92	9.8	16.0	11.5	9.5	7.9	3.3	3.6	-	-	8.9	***5.8***
1992/93	6.7	11.1	9.0	8.6	7.8	7.1	7.9	9.9	7.1	10.0	***6.8***
1993/94	8.9	17.1	12.8	15.5	13.4	6.3	11.3	11.8	7.7	14.7	***5.5***
1994/95	5.1	10.4	6.7	7.2	6.3	3.9	3.9	5.5	4.3	9.2	***3.3***
1995/96	4.4	9.4	4.7	4.7	6.9	6.2	7.1	7.9	5.4	11.5	***7.1***
1996/97	10.2	14.3	6.9	8.9	6.6	5.0	6.8	8.9	7.2	12.9	***12.4***
Ave	**7.5**	**13.1**	**8.6**	**9.1**	**8.2**	**5.3**	**6.8**	**7.3**	**5.3**	**11.2**	***6.8***

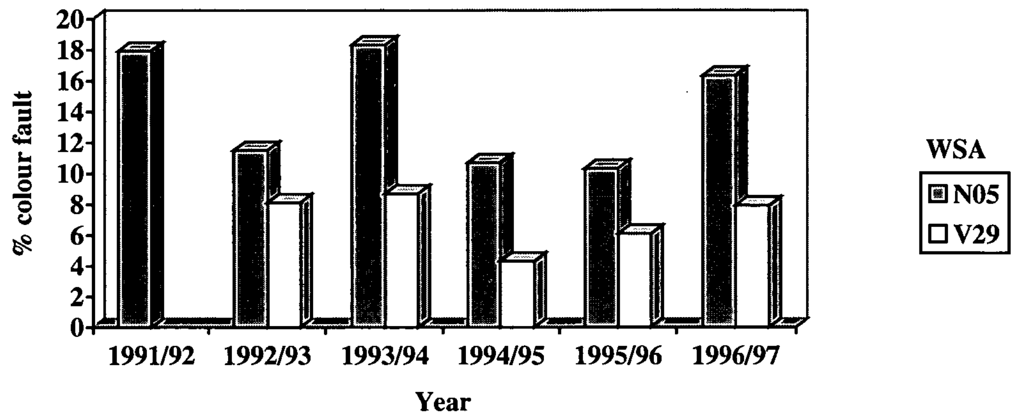


Figure 4.19: Difference in colour faults between N05 and V29 across seasons.

4.2.5 Strength

Strength faults are the most prevalent fault across the wool clip in NSW and Victoria. Strength of fleece wool varies greatly between WSA. Rotten (V) wool was not present at levels greater than 0.5% of fleece wool in NSW and 1.2% in Victoria across the six seasons.

Table 4.19: Percentage (%) of fleece wool with subjectively assessed tender (W2) wool.

Strength	WSA									
Fault	N03	N05	N17	N23	N24	V21	V22	V26	V29	V34	*TAS*
1991/92	1.0	1.9	5.1	5.3	1.5	8.4	7.4	-	-	6.1	***8.5***
1992/93	1.9	2.9	2.7	1.7	3.1	10.1	6.0	4.2	5.8	7.2	***6.2***
1993/94	1.6	0.9	2.6	2.2	1.8	10.1	4.4	4.6	5.9	5.9	***7.8***
1994/95	1.8	2.2	2.3	2.0	1.6	7.3	2.9	3.7	4.9	3.2	***5.7***
1995/96	1.8	1.5	3.9	5.3	4.4	6.8	6.8	5.4	3.9	3.9	***6.2***
1996/97	1.0	0.9	2.5	2.9	3.2	6.1	3.9	3.2	3.9	3.3	***3.2***
Ave	**1.5**	**1.7**	**3.2**	**3.2**	**2.6**	**8.1**	**5.2**	**3.5**	**4.1**	**4.9**	***6.3***

NSW and Victoria varied in the level of tender (W2) wool produced. In NSW tender (W2) wool did not exceed 5.4% of fleece wool whereas Victorian levels reached up to 10.1% of fleece wool in the six seasons studied (Table 4.19).

Table 4.20: Percentage (%) of fleece wool with subjectively assessed part-tender (W1) wool.

Strength Fault	WSA										
	N03	N05	N17	N23	N24	V21	V22	V26	V29	V34	*TAS*
1991/92	6.3	12.5	18.8	20.1	8.5	18.8	17.1	-	-	13.5	***19.4***
1992/93	7.0	11.0	8.7	8.2	9.8	19.4	14.8	11.2	14.2	12.6	***15.2***
1993/94	8.9	12.0	11.9	10.3	10.8	18.1	9.2	10	11.4	12.3	***14.9***
1994/95	6.5	8.7	14.6	10.5	10.7	14.1	6.4	10.1	9.2	6.4	***14.2***
1995/96	10.2	12.4	19.8	19.6	16.2	17.4	14.7	12.9	12.2	7.8	***13.4***
1996/97	5.6	7.4	12.3	10.8	13.6	14.1	10.6	8.4	8.8	6.1	***7.1***
Ave	**7.4**	**10.7**	**14.4**	**13.3**	**11.6**	**17.0**	**12.1**	**8.8**	**9.3**	**9.8**	***14.0***

Part-tender (W1) wool levels fluctuated across seasons and WSA (Table 4.20). N03 had the lowest levels of strength fault and V21 the highest within the ten WSA and across the six seasons (Figure 4.20).

The range in staple strength across seasons differs for NSW and Victoria. In NSW 1995/96 had the highest level of strength fault and 1992/93 the lowest. Whereas in Victoria, 1992/93 was the season with the highest level of strength fault and 1994/95 the lowest (Figure 4.21).

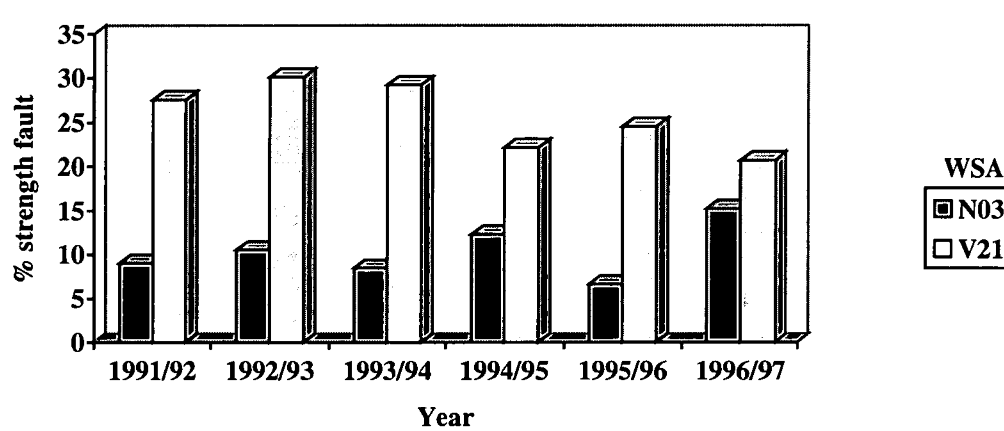


Figure 4.20: Differences in strength faults between N03 and V21 across six seasons.

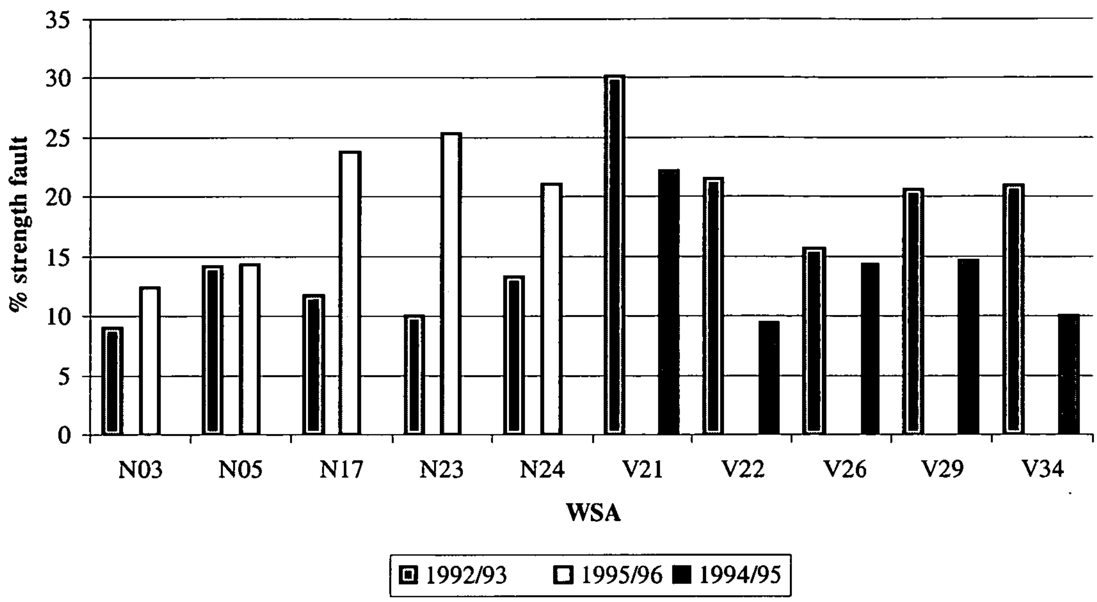


Figure 4.21: Differences in strength faults between WSA and the 1992/93, 1994/95 and 1995/96 seasons.

4.2.6 Vegetable Matter Content

NSW has a higher proportion of wool with greater amounts of vegetable matter than Victoria. The proportion of vegetable matter varied between both seasons and WSA. For burr (vml) content, levels were highest in N05 and N17 (Table 4.21). Victoria had no significant burr (vml) content at these levels. N05 was the only WSA that had more than 1% of fleeces with burr present at levels greater than 3%.

Table 4.21: Percentage (%) of fleeces with burr (vml) content at levels between 1.1% and 3% in each WSA.

Season	WSA									
	N03	N05	N17	N23	N24	V21	V22	V26	V29	V34
1991/92	2.5	24.2	4.9	1.1	0.1	0.1	0.1	-	-	0.1
1992/93	1.3	11.0	5.1	0.9	0.4	0.1	0.1	0.2	0.1	0.0
1993/94	2.6	18.9	7.2	2.2	0.6	0.2	0.4	0.8	0.4	0.3
1994/95	2.8	28.6	9.3	1.4	0.6	0.1	0.4	0.1	0.3	0.1
1995/96	1.4	22.1	4.8	1.2	0.5	0.0	0.4	0.1	0.0	0.0
1996/97	2.2	18.0	4.6	1.3	0.9	0.1	0.2	0.2	0.2	0.1
Ave	**2.1**	**20.5**	**6.0**	**1.4**	**0.5**	**0.1**	**0.3**	**0.2**	**0.2**	**0.1**

Table 4.22: Percentage (%) of fleeces with seed (vm2) content at levels between 1.1% and 3% in each WSA.

Season	WSA									
	N03	N05	N17	N23	N24	V21	V22	V26	V29	V34
1991/92	25.5	47.2	18.1	10.8	3.9	2.6	2.9	-	-	1.7
1992/93	27.8	41.6	38.5	15.3	17.2	1.9	1.9	0.8	0.8	2.5
1993/94	36.8	35.3	48.4	21.1	25.6	2.6	2.3	1.7	1.6	6.1
1994/95	17.3	47.9	40.9	10.9	2.2	2.2	1.0	0.7	0.5	1.5
1995/96	25.9	48.7	23.6	8.6	5.1	1.3	0.7	0.4	0.5	1.1
1996/97	38.3	50.2	35.9	22.4	22.8	4.1	2.4	1.0	1.2	3.1
Ave	**28.6**	**45.2**	**34.2**	**14.9**	**12.8**	**2.5**	**1.9**	**0.8**	**0.8**	**2.7**

Seed (vm2) was the vegetable matter present in the greatest quantity (Table 4.22). N05 and V21 had the greatest levels of seed for each state respectively. A seed level of 1.1 to 3% in Victorian wool did not exceed 6.1% of fleece wool produced across the six seasons. In NSW N03, N05 and N17 were the only WSA with levels greater than 3% seed (vm2) present, these levels varying from 0.2% to 5.6% of the fleece wool produced.

Table 4.23: Percentage (%) of fleeces with hardhead (vm3) content at levels between 1.1% and 3% in each WSA.

Season	WSA									
	N03	N05	N17	N23	N24	V21	V22	V26	V29	V34
1991/92	0.7	1.7	1.2	0.1	0	0	0	-	-	0
1992/93	0.7	3.1	7.8	0.4	0.2	0	0	0	0	0
1993/94	0.7	1.1	3.4	1.2	0.1	0.1	0.1	0.6	0.1	0.1
1994/95	0.4	1.1	0.9	0.6	0.1	0	0.1	0	0.1	0
1995/96	0.4	4.8	3.5	0.3	0.2	0	0	0	0.2	0
1996/97	0.7	5.6	5.4	0.3	0.0	0	0	0	0	0.1
Ave	**0.6**	**2.9**	**3.7**	**0.5**	**0.1**	**0**	**0**	**0.1**	**0.1**	**0**

The levels of hardheads (vm3) throughout the fleeces (Table 4.23) were generally below 1% except in N17 and N05. There was less than 1% of fleeces with more than 3% hardheads (vm3) present except in N17 where up to 2.5% of fleeces had greater than 3% hardheads (vm3).

Table 4.24: Percentage (%) of fleeces with vmb levels between 1.1% and 3% in each WSA

Season	WSA										*Ave*
	N03	N05	N17	N23	N24	V21	V22	V26	V29	V34	*Tas*
1991/92	34.0	69.0	38.0	17.9	7.2	4.0	4.1	-	-	3.4	***6.3***
1992/93	33.5	69.4	58.0	24.3	25.8	3.1	2.8	1.4	1.4	3.2	***7.0***
1993/94	43.0	59.2	65.5	30.1	33.1	4.4	4.2	4.1	2.5	7.6	***5.1***
1994/95	23.4	59.9	67.5	19.6	5.2	3.5	2.8	1.3	1.4	2.2	***1.9***
1995/96	35.4	68.8	54.1	14.9	11.4	1.9	1.9	0.8	1.2	1.5	***1.5***
1996/97	46.4	68.7	53.0	31.3	32.4	5.1	3.2	1.7	1.7	5.2	***1.6***
Ave	**36.0**	**65.8**	**56.0**	**23.0**	**19.2**	**3.7**	**3.2**	**1.6**	**1.4**	**3.9**	***3.9***

Vegetable matter base (vmb) at levels between 1.1 to 3% was present in up to 70% of fleeces in NSW and 8% in Victoria (Table 4.24). Variation occurred between the states (Figure 4.22), N05 had the highest levels of vegetable matter and V29 the lowest.

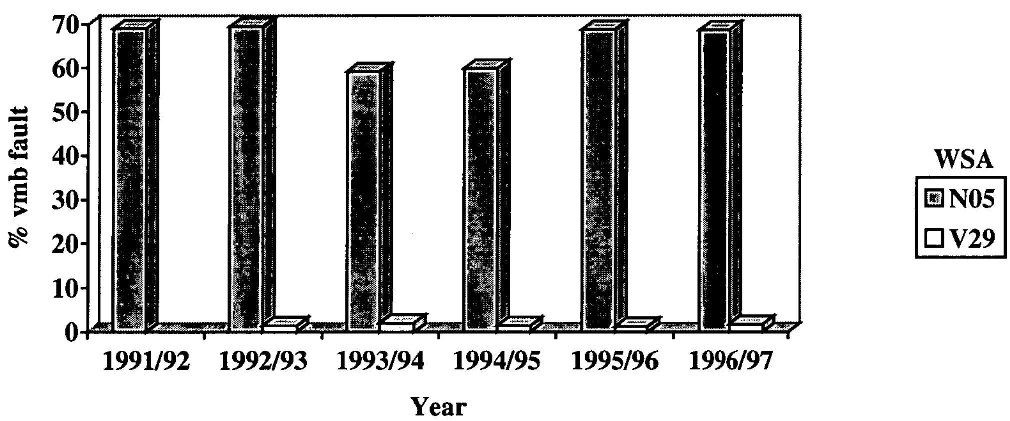


Figure 4.22: percentage (%) of fleece wool with vmb faults at levels between 1.1 to 3% in N05 and V29 across seasons.

Levels of Vmb greater than 3% (Table 4.25) did not occur in more than 0.5% of fleeces in Victoria. NSW had higher amounts of vmb than Victoria, especially in N05, N03 and N17.

Table 4.25: Percentage (%) of fleeces with vmb levels greater than 3% in each WSA.

Season	WSA									
	N03	N05	N17	N23	N24	V21	V22	V26	V29	V34
1991/92	3.3	14.5	3.7	0.7	0.1	0.0	0.1	-	-	0.1
1992/93	3.6	9.7	12.0	1.0	0.5	0.0	0.0	0.1	0.0	0.0
1993/94	4.2	15.2	9.5	1.9	0.9	0.1	0.2	0.5	0.3	0.3
1994/95	3.5	25.1	5.4	0.9	0.2	0.0	0.2	0.0	0.1	0.1
1995/96	2.9	17.5	4.3	0.7	0.3	0.0	0.0	0.1	0.1	0.0
1996/97	5.3	16.6	10.4	1.4	0.3	0.1	0.1	0.2	0.2	0.1
Ave	**3.8**	**16.4**	**7.6**	**1.1**	**0.4**	**0.0**	**0.1**	**0.2**	**0.1**	**0.1**

Differences between seasons were not consistent between WSA. Across all WSA the 1994/95 season had the least amount of vegetable matter present for NSW and Victoria and the 1993/94 season the greatest. However in N05 and N17 this was reversed (Figure 4.23).

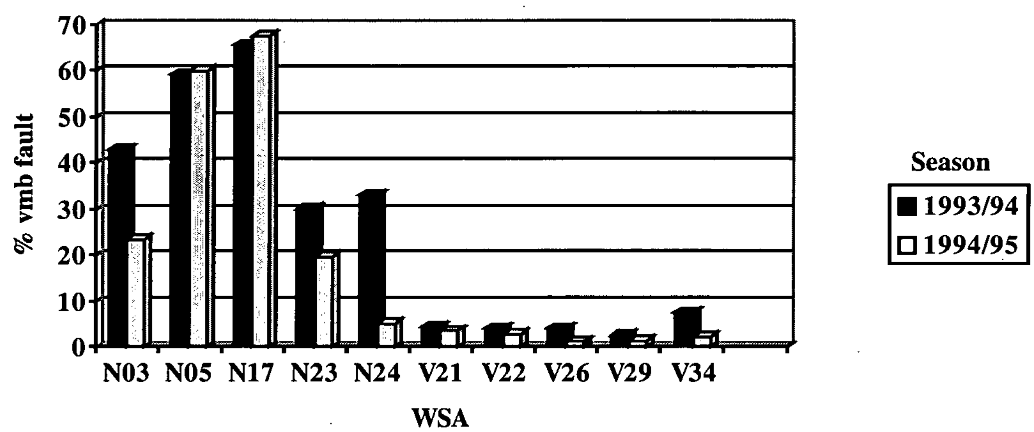


Figure 4.23: Differences between vmb (1.1-3%) levels across WSA and the 1993/94 and 1994/95 seasons.

4.3 The Influence of Wool Characteristics on Raw Wool Price

4.3.1 Introduction

Aim: To determine the influence of wool characteristics on the price of wool and if this influence differs between Tasmania, NSW and Victoria.

Fibre diameter, style, staple strength, staple length, vegetable matter and colour accounted for approximately 90% of the variance in clean price of merino wool sold at auction (IWS, 1995). The influence of various wool characteristics on price is examined in this section.

Prices received at auction for wool are volatile and vary greatly between seasons (Figure 4.24), with the clean price of wool varying from 400c/kg to 1500c/kg between the 1991/92 and 1996/97 seasons (for wool between 18.5μm-24μm). The effect of wool characteristics on price was calculated as a proportion of clean price, therefore allowing comparisons to be made between seasons without being distorted by the price fluctuations between seasons. Wool originating from Tasmania, NSW and Victoria were compared to determine if the influences of the wool characteristics on price varied between states.

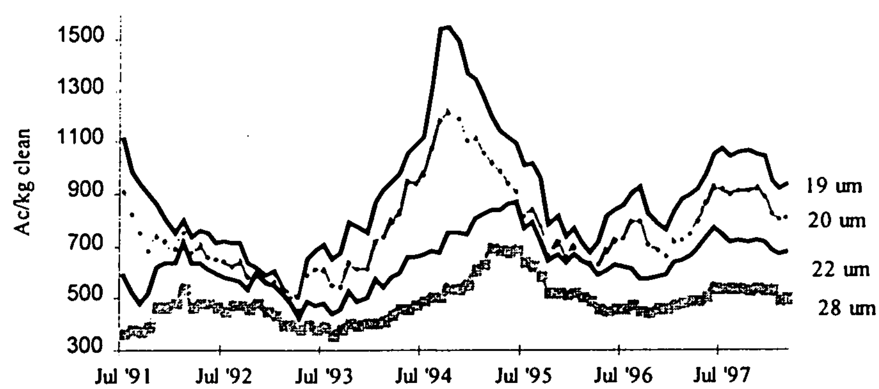


Figure 4.24: Movements in Micron Indicators (Monthly Averages) (IWS, 1997).

4.3.2 Clean Price

The clean price for fine wool was always higher than for medium, which in turn was higher than the strong wool for the seasons analysed, however there were no significant differences ($P<0.5$) in price between fine, medium and strong wool (Figure 4.25).

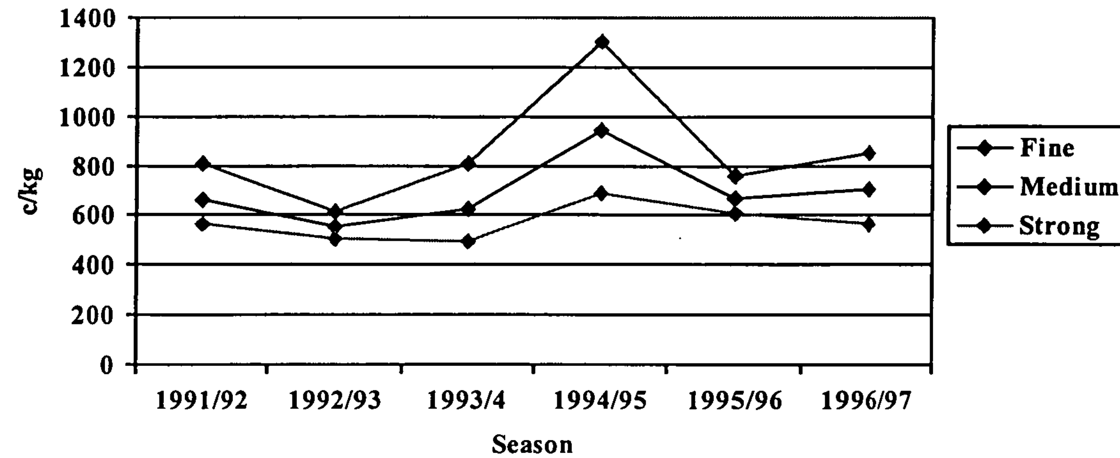


Figure 4.25: Average clean price (c/kg) received each season for combined State's (NSW, Victoria and Tasmania) fleeces.

There were no significant differences between states for clean prices in any season or for any fibre diameter group (Table 4.26).

Table 4.26: Average clean price (c/kg) received each season for NSW, Victorian and Tasmanian fleeces.

Season	Fine	Medium	Strong
1991/92	811 (155)	661 (95)	564 (87)
1992/93	613 (91)	555 (65)	504 (53)
1993/94	809 (152)	623 (126)	491 (62)
1994/95	1302 (245)	943 (137)	689 (95)
1995/96	761 (141)	668 (94)	607 (64)
1996/97	854 (201)	703 (126)	567 (62)

Brackets indicate standard deviations

4.3.3 Fibre Diameter

To minimise the influence of fibre diameter on wool auction price, the data was divided into three trade categories: fine, medium and strong wool (Section 3.3), as fibre diameter is the wool characteristic that has the largest influence on price (Section 2.8).

Price discounts for increased fibre diameter were greater within the fine wool category than the medium and strong wool (Table 4.27).

Price penalties for increased fibre diameter varied across seasons. In 1992/93 the fine Tasmanian wool received a 6.8% discount from clean price for each unit increase in fibre diameter. In 1993/94 the discount was 19.6% of clean price. There is no consistent difference between states in discounts for fibre diameter in fine wool, however generally all states increase or decrease in price penalties from one season to the next.

Table 4.27: Percent (%) discount, for each unit increase in fibre diameter, from clean price.

Fine Wool	**NSW**	**Victoria**	**Tasmania**
1991/92	9.1[t] (0.3)	9.5[t] (0.4)	12.0[nv] (0.7)
1992/93	7.4 (0.2)	8.3 (0.4)	6.8 (0.5)
1993/94	18.1 (0.2)	17.8 (0.3)	19.6 (0.6)
1994/95	19.1 (0.2)	18.3 (0.3)	18.5 (0.4)
1995/96	14.1 (0.3)	14.6 (0.3)	13.2 (0.5)
1996/97	18.0[v] (0.3)	14.6[n] (0.8)	17.5 (1.0)
Average	***14.3***	***13.9***	***14.6***
Medium Wool	**NSW**	**Victoria**	**Tasmania**
1991/92	10.2[t] (0.2)	10.3[t] (0.2)	8.1[nv] (0.3)
1992/93	4.9[t] (0.1)	4.9[t] (0.1)	3.6[nv] (0.2)
1993/94	14.4 (0.2)	14.6 (0.2)	13.7 (0.3)
1994/95	18.9[t] (0.1)	18.7[t] (0.1)	16.3[nv] (0.2)
1995/96	3.0 (0.2)	3.1 (0.1)	3.0 (0.7)
1996/97	9.7 (0.1)	9.6 (0.2)	8.2 (0.8)
Average	***10.2***	***10.2***	***8.8***
Strong Wool	**NSW**	**Victoria**	**Tasmania**
1991/92	8.8[t] (0.3)	7.7[t] (0.3)	4.5[nv] (0.3)
1992/93	4.9[v] (0.1)	5.6[n] (0.1)	5.0 (0.2)
1993/94	11.4[t] (0.2)	11.3[t] (0.2)	12.5[nv] (0.3)
1994/95	11.3[tv] (0.2)	10.2[n] (0.2)	9.4[n] (0.3)
1995/96	8.1 (0.3)	8.5 (0.2)	8.3 (0.4)
1996/97	12.3[t] (0.1)	11.9[t] (0.2)	10.8[nv] (0.2)
Average	***9.5***	***9.2***	***8.4***

[t] coefficient is significantly different from Tasmania's coefficient (P<0.01)
[n] coefficient is significantly different from NSW's coefficient (P<0.01)
[v] coefficient is significantly different from Victoria's coefficient (P<0.01)
brackets indicated standard deviations

In contrast, for medium wool, Tasmania had the lowest price discounts across the states for each season and there was a significantly ($p < 0.05$) lower price penalty than seen in NSW or Victoria in three seasons (1991/92, 1992/93 and 1994/95).

For strong wool, Tasmania's discount for fibre diameter was significantly different ($P<0.01$) from NSW and Victoria in 1991/92, 1993/94 and 1996/97, however it was not consistently higher or lower than the other states.

4.3.4 Yield

The effect of yield on clean price (Table 4.28) was determined using the combination of the three states data sets from each state as there was no significant effects due to yield in individual states. The effect of yield on clean price was greater in the fine wools. For every unit increase in yield the clean price rose by 0.4% for fine wool, 0.2% for medium wool and 0.1% for strong wool. The price effects on yield did not vary significantly ($P<0.5$) between seasons.

Table 4.28: Percent (%) increase in clean price for each unit increase in yield.

Wool type	%
Fine	0.4
Medium	0.2
Strong	0.1

4.3.5 Style

Style effects on clean price were not significantly different between the states, however when states were combined significant price effects ($P<0.5$) were obtained. 'Best Topmakers' was the predominant style. The other styles were then analysed to determine whether they received a price premium or discount in comparison to the prices paid for best topmakers fleeces.

Table 4.29: Percent (%) increase in price for each style category in fine, medium and strong wool across combined state fleeces, compared to best topmakers.

STYLE	Fine Wool	Medium Wool	Strong Wool
Choice	14.6	-	-
Super	8.5	0.6	0.3
Spinners	4.0	0.4	-0.7
Best Topmakers			
Good Topmakers	-2.5	-1.4	-0.3
Average Topmakers	-17.1	-9.5	-2.6
Good/Average Length	-8.2	-10.6	-6.7
Merino Fleeces	-11.4	-8.8	-3.3
Crossbred Fleeces	-12.0	-9.6	-3.9
Inferior Topmakers	-11.1	-11.3	-1.8
Short Fleeces	-14.0	-18.5	-11.3
Very Short Fleeces	-31.6	-23.7	-13.3

Style had a greater affect on price amongst fine wool. Short and very short styles received the greatest price penalty in each wool type (Table 4.29).

4.3.6 Colour

The discount for light colour (H1) fault across all seasons and states was greatest for finer wool. The price penalty was 3.3% of clean price for fine wool, 2.8% for medium and 2.4% for strong wool. The discounts for light colour had a significant difference ($P<0.01$) between some states and seasons (Table 4.30).

In Tasmania the relative price penalties increased as wool became coarser, with the price penalty for fine wool being 2% of clean price and 2.4% for strong wool. The reverse occurred in NSW and Victoria, with NSW having a 3.6% price penalty within fine wool and a 2.1% within strong wool.

Price penalties for medium colour (H2) fault decreased, as wool became stronger. The average price penalties for medium colour across all states and seasons were 9.2% for fine wool, 6.5% for medium and 5.9% for strong wool (Table 4.31).

Table 4.30: Price penalties (%) for light colour (H1) faults in fine, medium and strong wool in NSW, Victoria and Tasmania.

Fine Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	3.9 (0.4)	5.4^{t} (0.9)	0.7^{v} (1.4)	*3.5 (0.4)*
1992/93	4.3 (0.5)	4.3 (0.8)	2.6 (0.9)	*5.0 (0.4)*
1993/94	4.2^{v} (0.4)	2.1^{n} (0.6)	2.5 (1.3)	*3.9 (0.3)*
1994/95	2.2 (0.4)	1.6 (0.7)	3.1 (0.9)	*2.4 (0.4)*
1995/96	4.1^{v} (0.7)	1.6^{n} (0.6)	2.0 (0.8)	*6.5 (1.5)*
1996/97	2.6 (0.5)	1.3 (1.2)	1.2 (1.3)	*2.2 (0.5)*
Average	**3.6**	**2.7**	**2.0**	***3.3***
Medium Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	3.0 (0.3)	3.4 (0.6)	2.5 (0.6)	*2.6 (0.3)*
1992/93	2.9 (0.2)	2.5 (0.3)	2.9 (0.4)	*2.8 (0.2)*
1993/94	4.6^{tv} (0.3)	2.7^{n} (0.4)	2.6^{n} (0.7)	*4.6 (0.2)*
1994/95	2.3 (0.3)	2.5 (0.4)	2.3 (0.6)	*2.4 (0.2)*
1995/96	3.6 (0.4)	2.6 (0.3)	2.4 (1.5)	*2.9 (0.3)*
1996/97	2.3 (0.2)	2.1 (0.4)	-0.2 (1.2)	*1.6 (0.3)*
Average	**3.1**	**2.6**	**2.1**	***2.8***
Strong Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	2.3 (0.5)	3.0 (0.7)	3.2 (0.7)	*2.8 (0.4)*
1992/93	1.4^{tv} (0.2)	2.5^{n} (0.3)	2.8^{n} (0.4)	*2.5 (0.2)*
1993/94	2.7 (0.3)	1.9 (0.3)	2.3 (0.6)	*2.9 (0.2)*
1994/95	0.7 (0.4)	2.3 (0.5)	1.9 (0.9)	*1.5 (0.3)*
1995/96	3.4^{v} (0.5)	1.7^{n} (0.3)	3.6 (0.7)	*2.8 (0.3)*
1996/97	1.8^{t} (0.2)	1.5 (0.3)	0.7^{n} (0.3)	*1.7 (0.2)*
Average	**2.1**	**2.2**	**2.4**	***2.4***

^{t} coefficient is significantly different from Tasmania's coefficient (P<0.01)
^{n} coefficient is significantly different from NSW's coefficient (P<0.01)
^{v} coefficient is significantly different from Victoria's coefficient (P<0.01)
brackets indicated standard deviations

In general, the price penalties for medium colour fault within Tasmania were less than for the other states. However, these differences were usually not statistically significant (P<0.5) in any given year.

Table 4.31: Price penalties (%) for medium colour (H2) faults in fine, medium and strong wool in NSW, Victoria and Tasmania.

Fine Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	10.6 (1.4)	10.0 (2.7)	1.6 (3.5)	*9.6 (1.2)*
1992/93	9.0 (1.6)	14.5 (2.0)	8.4 (1.7)	*10.5 (1.1)*
1993/94	12.6^{tv}(1.2)	6.5^{n}(1.5)	3.7^{n}(3.0)	*10.6 (1.0)*
1994/95	16.3^{tv}(1.7)	6.1^{n}(1.9)	8.4^{n}(2.3)	*13.2 (1.3)*
1995/96	9.5 (2.6)	7.6 (1.8)	1.8 (2.1)	*6.5 (1.5)*
1996/97	6.3 (1.9)	5.0 (2.8)	3.6 (2.3)	*5.0 (1.3)*
Average	**10.7**	**8.3**	**6.0**	***9.2***
Medium Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	7.3^{t}(0.8)	6.3 (1.5)	3.0^{n}(1.4)	*6.2 (0.7)*
1992/93	7.1 (0.6)	7.0 (0.6)	7.0 (0.8)	*7.2 (0.4)*
1993/94	11.3^{tv}(0.7)	6.2^{n}(0.9)	5.5^{n}(1.7)	*9.4 (0.6)*
1994/95	7.4 (0.9)	5.0 (1.0)	7.0 (1.6)	*6.4 (0.6)*
1995/96	6.4 (1.4)	4.0 (0.6)	6.0 (3.2)	*5.1 (0.8)*
1996/97	5.5 (0.5)	5.3 (0.9)	3.9 (2.0)	*4.9 (0.6)*
Average	**7.5**	**5.6**	**5.4**	***6.5***
Strong Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	9.2 (1.4)	7.7 (1.8)	3.8 (1.7)	*7.2 (1.1)*
1992/93	4.5 (0.6)	5.5 (0.5)	6.1 (0.8)	*6.5 (0.4)*
1993/94	8.1^{v}(0.8)	4.4^{n}(0.6)	5.1 (1.4)	*6.3 (0.5)*
1994/95	5.4 (1.4)	4.9 (1.6)	4.5 (2.2)	*6.0 (1.1)*
1995/96	4.4 (1.3)	5.2 (0.6)	4.6 (1.4)	*5.6 (0.6)*
1996/97	3.4 (0.6)	3.7 (0.7)	3.0 (0.5)	*3.6 (0.4)*
Average	**5.8**	**5.2**	**4.5**	***5.9***

^{t}coefficient is significantly different from Tasmania's coefficient (P<0.01)
^{n}coefficient is significantly different from NSW's coefficient (P<0.01)
^{v}coefficient is significantly different from Victoria's coefficient (P<0.01)
brackets indicated standard deviations

The amount of heavy colour present in fleeces was low and hence no significant differences were available for individual states. Results were obtained from combining the three sets of data.

There was not substantial data with heavy colour fault for fine wool. Penalties for medium and strong wool varied between seasons. Standard deviations were high due to the low amount of data for heavy colour and variation in price received for the fault (Table 4.32).

Table 4.32: Price penalties (%) for heavy colour (H3) faults in medium and strong wool within all States.

Medium Wool	All States
1991/92	11.8 (3.0)
1992/93	6.8 (2.5)
1993/94	8.7 (2.9)
1994/95	-
1995/96	-
1996/97	6.8 (5.5)
Strong Wool	**All States**
1991/92	9.7 (5.0)
1992/93	10.0 (2.3)
1993/94	-
1994/95	-
1995/96	10.8 (2.2)
1996/97	3.8 (2.1)

brackets indicated standard deviations

4.3.7 Staple Strength

Penalties for strength fault were calculated individually for each state. The price penalties across states and seasons for part tender (W1) wool were a 7.1% discount in clean price for fine wool, 4.3% for medium wool and 1.8% for strong wool (Table 4.33).

Tasmania's price penalties for part tender wool were generally lower than the other states for fine and medium wool. In the fine wool Tasmania was significantly ($P<0.01$) lower than Victoria in the 1992/93, 1993/94, 1994/95 and 1996/97 seasons.

In strong wool there was no clear trend between the states for price penalties for part tender wool.

Table 4.33: Price penalties (%) for part-tender (W1) faults in fine, medium and strong wool in NSW, Victoria and Tasmania.

Fine Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	8.6^{v} (0.3)	10.4^{n} (0.4)	8.2 (0.8)	*9.9 (0.3)*
1992/93	4.7 (2.0)	6.9^{t} (0.5)	3.6^{v} (0.6)	*5.8 (0.3)*
1993/94	5.1^{v} (0.3)	9.2^{nv} (0.4)	4.8^{v} (0.8)	*5.7 (0.3)*
1994/95	3.9^{v} (0.3)	6.2^{nt} (0.3)	3.5^{v} (0.4)	*4.9 (0.2)*
1995/96	9.1^{t} (0.4)	9.7^{t} (0.4)	5.2^{nv} (0.6)	*9.4 (0.3)*
1996/97	5.8 (0.4)	8.2 (0.9)	4.6 (1.4)	*6.7 (0.4)*
Average	**6.2**	**8.4**	**5.0**	***7.1***

Medium Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	5.4 (0.3)	4.9 (0.4)	4.7 (0.4)	*4.8 (0.2)*
1992/93	4.7 (0.2)	4.7 (0.2)	5.0 (0.3)	*4.9 (0.1)*
1993/94	4.9^{v} (0.3)	7.1^{nt} (0.3)	3.4^{v} (0.5)	*4.7 (0.2)*
1994/95	3.3^{t} (0.3)	3.4^{t} (0.3)	2.0^{nv} (0.4)	*3.0 (0.2)*
1995/96	4.8 (0.3)	4.9 (0.2)	4.1 (1.2)	*4.9 (0.2)*
1996/97	3.3 (0.2)	3.6 (0.4)	2.9 (1.5)	*3.6 (0.3)*
Average	**4.4**	**4.8**	**3.7**	***4.3***

Strong Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	1.8 (0.6)	2.7 (0.5)	1.8 (0.5)	*1.0 (0.4)*
1992/93	3.1^{v} (0.3)	2.0^{n} (0.2)	2.8 (0.3)	*2.8 (0.2)*
1993/94	0.7^{v} (0.4)	3.0^{nt} (0.3)	1.3^{v} (0.5)	*1.1 (0.3)*
1994/95	-0.4 (0.5)	0.1 (0.5)	1.2 (0.6)	*0.0 (0.0)*
1995/96	3.5 (0.4)	3.8 (0.3)	3.0 (0.6)	*3.7 (0.2)*
1996/97	1.8 (0.3)	2.5 (0.3)	2.3 (0.4)	*2.3 (0.2)*
Average	**1.8**	**2.4**	**2.1**	***1.8***

^{t}coefficient is significantly different from Tasmania's coefficient (P<0.01)
^{n} coefficient is significantly different from NSW's coefficient (P<0.01)
^{v} coefficient is significantly different from Victoria's coefficient (P<0.01)
brackets indicated standard deviations

Price penalties for tender wool (W2) were at least double those received for part tender wool. Fine wool lost 14.1% of clean price, when averaged across states and seasons, with medium wool losing 10.6% and strong wool 6.7%.

In fine wool, price penalties for Tasmania were significantly lower than Victoria (P<0.5) in the 1991/92, 1992/93, 1993/94, 1994/95 and 1995/96 seasons. Tasmania's price penalties for tender wool followed the general trend of being lower than the *'All States'* price penalties (Table 4.34), however the difference was not significant.

Table 4.34: Price penalties (%) for tender (W2) faults in fine, medium and strong wool in NSW, Victoria and Tasmania.

Fine Wool	NSW	Victoria	Tasmania	*All States*
1991/92	18.8^{tv} (0.6)	21.6^{nt} (0.6)	14.1^{nv}(1.2)	*19.9 (0.4)*
1992/93	7.2^{v} (0.7)	13.6^{nt} (0.6)	9.3^{v} (1.0)	*11.0 (0.5)*
1993/94	12.5^{v} (0.7)	18.0^{n} (0.6)	12.2^{v} (1.1)	*14.0 (0.5)*
1994/95	8.8^{v} (0.7)	13.4^{nt} (0.5)	10.8^{v} (0.7)	*11.3 (0.4)*
1995/96	15.8^{t} (0.7)	17.6^{t} (0.5)	12.4^{nv}(0.8)	*16.4 (0.4)*
1996/97	10.7 (0.9)	13.8 (1.4)	4.6 (1.4)	*11.8 (0.7)*
Average	**12.3**	**16.3**	**10.6**	***14.1***
Medium Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	13.3^{t} (0.5)	14.6^{t} (0.5)	10.8^{nv} (0.5)	*12.7 (0.3)*
1992/93	8.3^{tv} (0.4)	11.6^{n} (0.3)	10.4^{n} (0.5)	*10.8 (0.2)*
1993/94	12.0^{nv}(0.6)	17.9^{nt} (0.4)	13.3^{v} (0.7)	*13.4 (0.4)*
1994/95	8.3 (0.6)	9.4 (0.4)	9.5 (0.5)	*9.2 (0.3)*
1995/96	10.3 (0.6)	9.9 (0.3)	7.7 (1.6)	*9.9 (0.4)*
1996/97	6.4 (0.3)	8.1 (0.6)	7.7 (2.3)	*7.3 (0.5)*
Average	**9.8**	**11.9**	**9.9**	***10.6***
Strong Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	7.5 (1.4)	10.5 (0.8)	8.0 (0.8)	*7.8 (0.7)*
1992/93	8.1 (0.6)	7.4 (0.3)	6.6 (0.6)	*8.0 (0.3)*
1993/94	7.1 (1.0)	9.9^{t} (0.4)	6.8^{v} (0.7)	*7.5 (0.4)*
1994/95	4.7 (1.6)	4.7 (0.8)	6.4 (0.9)	*5.4 (0.6)*
1995/96	6.9 (0.8)	6.8 (0.4)	5.1 (1.0)	*7.0 (0.4)*
1996/97	4.2 (0.6)	4.2 (0.5)	5.4 (0.6)	*4.5 (0.4)*
Average	**6.4**	**7.3**	**6.4**	***6.7***

^{t}coefficient is significantly different from Tasmania's coefficient (P<0.01)
^{n} coefficient is significantly different from NSW's coefficient (P<0.01)
^{v} coefficient is significantly different from Victoria's coefficient (P<0.01)
brackets indicated standard deviations

The price penalty for rotten wool (V) was slightly higher than tender wools. However in the fine wool there was no significant differences (P<0.5) (Table 4.35).

Table 4.35: Price penalties (%) for rotten (V) faults in fine, medium and strong wool in NSW, Victoria and Tasmania.

Fine Wool	NSW	Victoria	Tasmania	*All States*
1991/92	19.3 (2.2)	21.0 (1.8)	19.7 (3.3)	*20.8 (1.4)*
1992/93	15.0 (0.3)	15.8 (2.6)	0 (0)	*14.9 (1.7)*
1993/94	19.4 (5.6)	19.1 (2.0)	13.0 (2.8)	*14.8 (1.8)*
1994/95	5.9 (4.4)	15.9 (1.7)	13.4 (2.1)	*13.8 (1.6)*
1995/96	17.5 (2.8)	19.1 (1.8)	11.8 (2.6)	*17.6 (1.6)*
1996/97	12.1 (3.6)	14.0 (5.1)	16.1 (7.1)	*12.3 (2.8)*
Average	**14.9**	**17.5**	**12.3**	***15.7***
Medium Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	17.8 (1.7)	17.4 (1.4)	13.4 (1.8)	*16.2 (1.0)*
1992/93	13.3 (1.4)	12.9 (0.8)	14.5 (1.7)	*13.7 (0.7)*
1993/94	11.5[tv] (2.4)	21.3[n] (1.3)	19.5[n] (1.6)	*16.0 (1.2)*
1994/95	8.0 (1.9)	12.3 (1.1)	14.1 (1.6)	*12.0 (0.9)*
1995/96	11.8 (2.1)	11.9 (1.0)	11.4 (5.7)	*12.2 (1.3)*
1996/97	8.0 (1.0)	9.7 (1.9)	9.7 (7.4)	*10.0 (1.6)*
Average	**11.7**	**14.3**	**13.8**	***13.4***
Strong Wool	**NSW**	**Victoria**	**Tasmania**	***All States***
1991/92	13.2 (4.0)	12.3 (2.4)	8.9 (3.1)	*10.7 (2.3)*
1992/93	6.0 (1.9)	8.7 (0.9)	11.1 (1.8)	*8.6 (0.9)*
1993/94	4.5 (3.8)	11.5 (1.3)	9.7 (1.8)	*8.9 (1.2)*
1994/95	10.3 (4.5)	10.3 (2.1)	10.0 (3.4)	*9.9 (1.9)*
1995/96	15.2 (2.7)	8.1 (1.5)	8.6 (3.1)	*11.1 (1.4)*
1996/97	6.6 (2.2)	5.5 (1.7)	7.0 (2.0)	*7.6 (1.2)*
Average	**9.3**	**9.4**	**9.2**	***9.5***

[t] coefficient is significantly different from Tasmania's coefficient (P<0.01)
[n] coefficient is significantly different from NSW's coefficient (P<0.01)
[v] coefficient is significantly different from Victoria's coefficient (P<0.01)
brackets indicated standard deviations

4.3.8 Vegetable Matter

The effects of burrs (vm1), seeds (vm2) and hardheads (vm3) on clean price of wool were determined for each state. However there was not enough data within Tasmania and Victoria to obtain individual price penalties. As a result, price penalties for vegetable matter were calculated for all states and years combined.

Burr and hardhead relative price penalties decreased as wool became coarser whereas seed price penalties were lower with the finer wool (Table 4.36).

Table 4.36: Price penalties (%) for each unit increase in burr (vml), seed (vm2) and hardhead (vm3) in fine, medium and strong wool for all states

	Burr	Seed	Hardhead
Fine	2.2	1.2	1.9
Medium	2.1	1.4	1.6
Strong	1.9	2.2	1.0

4.4 Cost of wool faults to Tasmania, New South Wales and Victoria

4.4.1 Introduction

Aim: To determine the cost of wool faults in Tasmania, NSW and Victoria.

The impact of wool faults to each state varies. The cost is influenced by the occurrence of the fault throughout the state's clip as well as the price penalty imposed for the fault within that state.

4.4.2 Style

As the effects for style were not significant (P<0.5) for each state (Section 4.3) it is not possible to determine the individual costs of different styles to each state.

4.4.3 Colour

The cost of colour fault varies between states. The loss is greater as the wool becomes finer. In the fine wool Tasmania lost 0.4 c/kg which is less than NSW (0.5 c/kg) but greater than Victoria (0.3 c/kg).

In the medium wool Tasmania (1.9 c/kg) is once again between NSW (2.3 c/kg) and Victoria (1.7 c/kg) (Table 4.37).

For the strong wool Tasmania lost only 1.3 c/kg which is less than both NSW (1.8 c/kg) and Victoria (1.6 c/kg). Colour fault has a greater effect on price in the medium to strong wool categories.

NSW had the greatest loss over the whole wool clip as it had the highest amount of colour fault on average across the three states and six seasons (Section 4.1 & 4.2) as well as incurring the highest price penalties for colour (Section 4.3).

Table 4.37: Amount lost (c/kg) over all wool for colour faults for each state

Fine Wool	NSW	Victoria	Tasmania
1991/92	0.7	0.2	0.3
1992/93	0.3	0.3	0.4
1993/94	0.8	0.4	0.2
1994/95	0.5	0.2	0.2
1995/96	0.2	0.2	0.5
1996/97	0.4	0.3	0.7
Average	**0.5**	**0.3**	**0.4**
Medium Wool	**NSW**	**Victoria**	**Tasmania**
1991/92	2.3	0.9	1.5
1992/93	1.8	1.5	2.0
1993/94	5.2	3.3	2.1
1994/95	1.9	1.5	0.8
1995/96	1.3	1.7	2.0
1996/97	1.3	1.1	3.0
Average	**2.3**	**1.7**	**1.9**
Strong Wool	**NSW**	**Victoria**	**Tasmania**
1991/92	2.3	1.1	1.3
1992/93	1.6	2.1	1.4
1993/94	2.9	2.4	1.1
1994/95	1.0	0.8	0.6
1995/96	1.5	2.0	2.1
1996/97	1.2	1.2	1.5
Average	**1.8**	**1.6**	**1.3**

4.4.4 Strength

Tasmania and Victoria lost more for strength fault across all types of wool than NSW. Tasmania lost 3.4 c/kg and Victoria lost 4.1 c/kg for all fine wool produced throughout the state due to strength faults whereas NSW lost 3.2 c/kg.

In the medium wool Tasmania lost 10.2 c/kg and Victoria 8.5 c/kg, and for strong wool both Tasmania and Victoria lost 3 c/kg. Therefore the cost of strength faults is greatest to the states amongst the medium wool (Table 4.38).

These results are consistent with results in previous sections as Victoria on average had a higher quantity of strength fault than Tasmania (Section 4.1 &4.2). Also Victoria had the higher price penalties for tender wool, whereas Tasmania generally had price penalties similar to NSW (Section 4.3). Tasmania had a higher proportion of strength fault than NSW making the cost to Tasmania's wool clip higher than NSW (Table 4.38).

Table 4.38: Amount lost (c/kg) over all wool for strength faults for each state

Fine Wool	NSW	Victoria	Tasmania
1991/92	6.0	7.9	6.2
1992/93	0.9	2.0	1.3
1993/94	1.7	2.6	2.3
1994/95	3.0	3.5	3.6
1995/96	5.3	5.3	4.7
1996/97	2.4	3.2	2.2
Average	3.2	4.1	3.4
Medium Wool	**NSW**	**Victoria**	**Tasmania**
1991/92	7.4	11.6	15.4
1992/93	4.4	9.3	8.6
1993/94	5.8	10.1	12.4
1994/95	4.7	7.2	11.0
1995/96	9.5	8.8	9.5
1996/97	4.4	4.2	4.0
Average	6.0	8.5	10.2
Strong Wool	**NSW**	**Victoria**	**Tasmania**
1991/92	1.3	3.8	3.7
1992/93	1.4	4.7	3.3
1993/94	0.8	2.2	3.6
1994/95	0.2	1.1	1.4
1995/96	3.8	4.5	4.7
1996/97	1.4	1.7	1.4
Average	1.5	3.0	3.0

4.4.5 Vegetable Matter

As the effects for vegetable matter were not significant ($P<0.5$) between states (Section 4.3) it is not possible to determine the individual costs of vegetable matter types to each state.

Chapter Five: Discussion

5.1 Characterisation of the Tasmanian Clip

5.1.1 Tasmanian Production and Fibre Diameter

Tasmania contributes around 2-3% of Australia's total wool production. Even though the amount of wool produced is small there are large differences in wool quality throughout the state and between seasons.

The total production of wool varied little between the six seasons within Tasmania. T04 and T05 produced the largest amount of wool from the ten WSA analysed and grazed the largest proportion of sheep within Tasmania from the north coast through to the midlands. T10 and T06 contribute a significant proportion of wool to Tasmania the total area of these two WSA is however notably smaller than T04, T05 and T03.

It is important to note that the WSA boundaries are not representative of climatic or geographic changes or any other production related factors but are based on Australian Geographical Classifications introduced by the Australian Bureau of Statistics. As a result, it is difficult to classify the wool type coming from any particular area as all areas encompass a variety of climatic conditions and breeds and bloodlines of sheep.

Table 5.1: Annual precipitation (1991/92-1996/97) for major centres within WSA

Town	**WSA**	**90/91**	**91/92**	**92/93**	**93/94**	**94/95**	**95/96**	**96/97**	**Ave** (90/91-96/97)
Ross	T03	-	-	-	-	*410*	**624**	**502**	***470***
St Helens	T03	*611*	**902**	*693*	**983**	*662*	*690*	*556*	***776***
Scottsdale	T03	*999*	**1151**	**1208**	*1013*	*793*	*877*	*869*	***1040***
Hamilton	T05	*455*	**506**	**494**	**479**	*421*	-	-	***476***
Ouse	T05	*504*	**632**	**549**	**575**	**573**	**658**	*516*	***548***
Orford	T06	*564*	*542*	*536*	*554*	*584*	**943**	*536*	***688***
Swansea	T06	*536*	*452*	*410*	*538*	*504*	**738**	*404*	***599***
Flinders Island	T10	*698*	**909**	-	*674*	*606*	*698*	*551*	***762***

bold: indicates rainfall is above average, *italic:* indicates rainfall is below average

The variation in climatic conditions within and between the WSA are highlighted in Table 5.1 through the examination of rainfall data for various population centres within each WSA.

T03, which includes Ross, St Helens and Scottsdale, had the greatest variation, from 470mm/annum to 1040mm/annum, in average precipitation within a WSA. Variation in annual precipitation did occur in other WSA but was not as pronounced. Climatic differences between seasons and year has been shown, in Tasmanian trials, to influence the botanical composition of pastures (Ball, 1998). Intensive monitoring of botanical composition in Tasmanian trials carried out within T05 and T03 have clearly shown significant changes in species composition between years (Thompson and Ball, 1997) with pasture production being directly related to rainfall (Ball, 1998).

Although precipitation will influence pasture production its direct relationship to wool production is not known. Studies by Ball (1998) compared Tasmanian wool production against rainfall in both Oatlands (T05) and Launceston (T04) and found no obvious or consistent relationship between wool production and rainfall and therefore concluded that other factors must have been exerting greater influences on wool production.

The breed or type of sheep present will also influence the quality of wool produced. Some differences in wool quality between WSA were observed. Flinders Island had the largest proportion of strong wool, which is directly related to the medium to strong bloodlines of the sheep within T10. T03 and T06 had the finest wool, which demonstrates that a large percentage of Tasmania's fine wool is produced on the east coast. T04 has a higher fibre diameter of wool as it includes the area in the north of the state that has a high prime lamb production and therefore a large proportion of crossbreed sheep.

From the data it was observed that the entire Tasmanian wool clip is becoming progressively finer. This is influenced by the increased number of merinos at the expense of other dual-purpose breeds which have traditionally been used for broader wool and meat production (*pers com.* R.Wallace), although there is also an increasing number of specialist prime lamb enterprises in the state, in which there is little or no emphasis on wool production.

To determine the 'other' influences on the differences in wool production throughout the state, the quality of wool was determined from both objective data collected at Tasmanian wool sales, such as fibre diameter, yield and vegetable matter and subjective appraisal data such as colour, style and strength.

Due to the relatively slow uptake of objective measurements it was not possible to included objectively measured strength, position of break or length, as only the 1996/97 data (>85% of lots sold) had a sufficient amount of fleece wool with objective measurements to permit an analysis. In Tasmania in 1995/96 less than 50% of fleece wool was objectively measured, while in 1991/92 it was only 8%.

5.1.2 Yield

Yield measurements take into account contaminants such as dust, moisture, grease and vegetable matter. Within Tasmanian wool the biggest variation in yield was due to difference in fibre diameter (Figure 4.9). The yield of Tasmanian wool varied little between WSA with the majority of wool below 20μm yielding around 70-75% and wool coarser than 20μm yielding around 75-80%. This is supported by previous research where higher yields are associated with coarser and longer wools (Whiteley *et al.,* 1980). T04 had a slightly higher yield than other areas in Tasmania this may be due to both the large population of crossbreeds within this region and the increased sweat leeching due to the high rainfall in T04.

5.1.3 Style

Appraised style is highly correlated with yield, length and greasy colour. Style takes into account a number of other features of wool relating to its general appearance including crimp frequency and definition, tip shape, dust penetration and weathering.

Style variations may also occur due to differences in breeds, as breed influences crimp frequency characteristics, yolk composition and staple structure (Jackson and Rottenbury, 1994). This was demonstrated by the large proportion of wool in T04 that fell into the lower grades, such as good topmakers, due to the presence of crossbred fleeces within T04.

From the Tasmanian data it was shown that the largest influence on style was change in seasonal environment as style levels varied between seasons. This is consistent with literature where style is largely a reflection of the environment (Ford and Jackson, 1994; Jackson and Rottenbury, 1994). Style is influenced notably by the environment as changes in season may vary the yield, colour, vegetable matter content or strength of the fleece hence indirectly altering the style.

5.1.4 Colour

Research has shown that the environmental conditions play a large role in the discolouration of wool (Thompson, 1988; Rogan, 1995). In Tasmania the levels of colour fault were not high, with H3 colour rarely occurring throughout the six seasons, however seasonal conditions were observed to have the greatest influence on the colour of fleece wool.

The seasonal impact on colour faults in wool is demonstrated by the variation in colour fault levels across the six seasons. The 1994/95 season had the lowest incidence of colour fault and this season also had below average rainfall (Table 5.1), whereas the 1996/97 season had very high levels of colour fault with above average rainfall levels, throughout most of the state, in 1996. This correlates with previous research (Thompson 1988; Rogan, 1995) which demonstrated that high rainfall conditions may induce yellowing and staining in the fleece (Rogan, 1995) as yellowing and bacterial stains, or fleece rot, are associated with damp conditions within the fleece.

Flinders Island had the lowest incidence of colour fault. This may be contributed to by the slightly drier climate present on Flinders Island (Table 5.1) compared to mainland Tasmania. However other research (Atkins *et al.*, 1994) has shown substantial variation between merino bloodlines in levels of greasy colour. Hence the low levels of colour in Flinders Island's fleeces is likely to be the combination of low annual rainfall and the presence of a bloodline of sheep that is less susceptible to colour fault.

Tasmania has little problem with medium and heavy unscourable colour, which may be contributed to the bloodlines of Tasmanian sheep having low susceptibility to colour. T04 had the only significant levels of medium unscourable colour fault. T04 also had the highest levels of light unscourable faults. Therefore T04 was the only WSA within Tasmania in which colour levels varied greatly from other WSA. Rogan (1995) demonstrated that wool colour is also influenced by breed of sheep and crossbred sheep have fleeces which are generally less bright and white than merinos. Hence as T04 has a large proportion of crossbred sheep it is thought that this contributes to the higher occurrence of colour.

As breeds influenced wool colour, producers may select for breeds or bloodlines, which are less prone to discolouration to reduce colour fault, if it is significantly reducing the value of their wool.

All the colour measurements analysed were subjective due to no objective measurement for colour being available at the time of the analyses. However, the recent introduction of a commercially available objective colour test, which Tasmanian leads nationally with respect to adoption rate, will ensure that only wools with unscourable colour are discounted and may support anecdotal evidence that has suggested Tasmania has the highest clean colour of all Australian states (pers com. E.Hutchinson).

5.1.5 Staple Strength

The staple strength of Tasmanian wool has increased over the six seasons. In 1991/92 over 20% of the fleece wool in every WSA had strength faults whereas in 1995/96 and 1996/97 strength faults had decreased in most cases to below 15% of the fleece wool. This has probably arisen due to the increased awareness amongst producers of a problem with wool strength. Two factors contributed to this awareness.

Firstly, the removal of the reserve price scheme in 1991. In the past producers often were not aware of a discount for tender wool due to the premiums paid for finer wool. As the tender lines had a lower fibre diameter than the sound lines, in most cases they tended to obtain a greater price hence alleviating any penalties for strength faults. After the removal of the reserve price scheme the premiums paid for lower fibre diameters were diminished with penalties for faults within the fleeces being highlighted (*pers com* M.Best).

Secondly, the increase in objective measurements for strength. In 1991/92 an average of 8% of producers had their fleeces objectively measured for strength whereas in 1996/97 85% of fleeces, on average, were objectively measured for strength. This increased uptake of objective measurement allowed producers to identify strength problems within their flocks.

As producers became more aware of the strength problem they began to identify management events which influence strength of the fleece and previous research has shown that a variety of physiological and environmental factors are known to influence the strength of wool fibres (Reis, 1992).

Masters *et al.* (1998) demonstrated that a major reason for low staple strength was the variability in fibre diameter associated with the seasonal changes in pasture availability and quality. A distinct period of optimum weather may cause a flush in pasture growth, which may lead to changes in nutrient supply. Alternatively a sudden dry spell may cause a reduction in pasture growth, leading to feed stress. These alterations in nutrient availability may increase the rate of change in fibre diameter and thereby alter staple strength (Peter *et al.*, 1994). The high levels of staple strength faults illustrate this in the 1991/92 season in Tasmania.

The 1990/91 season was very dry (Table 5.1) and was followed by an above average season in 1991/92, which created a large variation in feed between seasons and may have increased the incidence of breaks within the fleeces due to the change in nutrition.

The 1995/96 season had an above average rainfall and was followed by a below average season in 1996/97, however the occurrence of strength faults was reduced from the previous seasons. This may have been due to a gradual change in seasonal conditions rather than an abrupt change. However, after discussions with brokers in Tasmania, it is thought that the low incidence of strength faults was due mainly to increased awareness amongst producers which resulted in effective management of their flocks to reduce strength faults (*pers com* M.Best, R.Wallace).

Changes in management practices are thought to have contributed to a reduction in staple strength over the six seasons. A shift in shearing dates was observed by brokers (*pers. com* M.Best, R.Wallace) as awareness developed amongst producers, that to shear when the break in the wool was at either the tip or base of the staple would reduce the tested incidence of tenderness.

This was confirmed by Tasmanian research (Butler 1992) which determined that the trough of wool production and position of break tend to occur in autumn-winter in Tasmania and that possible management strategies to improve staple strength include choice of shearing date to coincide with position of break.

It was thought that the extent of the shift in shearing dates might be demonstrated by the amount of wool being offered for auction, with more wool becoming available at sales in autumn/winter rather than spring/summer. However, this was not possible to determine from the auction data due to the bias in Tasmania caused by the majority of producers selling at the infrequent Launceston sales.

Other factors that may have influenced the decrease in strength faults are the change in mob ratios. A higher proportion of ewes in the flock may result in a higher proportion of tender wool due to the increased physiological stress on ewes from pregnancy and lactation (Corbett, 1979), however if the mob has a higher proportion of wethers it would allow for a slight increase in staple strength. As the Tasmanian wool industry has been moving away from prime lamb production (*pers. com* M.Best) and towards wool production it is likely that the proportion of wethers to ewes has increased slightly and this will contribute to a slight increase in staple strength in Tasmanian wool from 1991/92 to 1996/97.

Strength faults can also be cause by physiological stresses on the animal resulting in poor health such as flystrike or helminths. The successful introduction of Wormplan into Tasmania in the early 1990's and the rapid uptake by producers has reduced the occurrences of internal parasites and indirectly reduced strength faults caused by internal parasite stress (*pers com.* A.Bailey).

It was observed that T04 had a slightly higher incidence of strength faults than other WSA. Most farms within T04 have mixed cropping and prime lamb enterprises, with wool production being a secondary income earner. As wool production is not the major enterprise, management is not focused on wool production and strength faults may be more pronounced due to the management influence of prime lambs.

The occurrence of staple faults is high throughout the Tasmanian wool clip, however the number of strength faults did decrease over the six seasons. With wide adoption of objective measurement for strength and position of break, farmers should be able to identify key management events that are reducing staple strength. If low staple strength is reducing the return they are receiving for their wool clip, simple management changes should be able to increase the staple strength and hence their return. The staple strength problems throughout Tasmania seem to be mainly attributed to management factors and not environmental influences.

5.1.6 Vegetable Matter

To determine the extent that vegetable matter reduces the quality of Tasmanian wool the vegetable matter base levels must be observed rather than the category of vegetable matter present. Vegetable matter base must exceed 1.1% of the fleece before it will incur a price penalty.

Vmb levels in Tasmanian wool are very low, in most cases at least 95% of the wool clip is classified as free or nearly free of vegetable fault. This is consistent with research (Rogan, 1995) which observed that wool grown in high rainfall areas contains lower vegetable matter content than wool grown in semi-arid pastoral zones. There appears to be no trend in amount of vm present in wool between seasons.

Seasonal variation seems to have the largest influence on vm content. This is expected as the major contributor to variation in the extent and type of vegetable matter contamination in wool is the composition and growth characteristics of pasture grazed by the sheep (Lunney, 1981). This trend is highlighted by Tasmanian data. The 1991/92 and 1992/93 seasons had the greatest amount of vegetable matter fault. Rainfall within 1991/92 and the 1992/93 season were above average especially in T05, producing good pasture growth as well as increased pastures/weeds that produce vm therefore producing an increase in contaminated wool.

T05 consistently had the higher levels of vmb and T10 the lowest. This could be due to a number of reasons. The pasture content varies in both areas with T05 having grass species that are more susceptible to contribute to vegetable matter contamination. Grazing pressure may be different, with T10 having higher stocking rates, reducing seeding of grass species and therefore contamination. If pasture species are grazed at certain times pasture may be shorter when seeding occurs and therefore come in contact with legs, belly and face of sheep. This type of contamination is easier to remove during skirting of fleece, whereas tall pastures with seeds that will lodge in the back and side of the sheep contaminate the whole fleece making removal of vegetable matter through skirting more difficult.

The majority of vm within Tasmanian wool is seed fault. Due to finer and subtler nature of seed species, these vm are difficult to remove in carding (Bow *et al.*, 1989). At present vm faults are not penalised by their type but purely on content, however this may change with processors commenting that to lessen the effects of vm contamination improved description is essential if the wool industry is to adapt to future economic pressures (Atkinson, 1989).

Time of shearing will also influence vm contamination and shearing may occur in T10 just before grass species seed. Seeds are less likely to lodge in short wool (Johnston, 1992). Fleece presentation such as skirtings, may also influence the amount of vm content, with effective skirting around the neck and legs and the removal of the belly reducing the vm contamination of the fleece wool.

In principle there are several ways in which vm contamination in Tasmanian wool might be reduced but the economic implications of vm needs to be first examined to determine whether it is viable and necessary to reduce the already low levels of vm in Tasmanian wool.

5.2 Comparison of NSW, Victorian and Tasmanian Clips

5.2.1 Introduction

Tasmanian wool production is significantly less than NSW and Victoria. Across the six seasons of 1991/92 to 1996/97 Tasmania produced on average 2.5% of Australia's wool, compared to NSW's 34% and Victoria's 19%.

Areas in NSW and Victoria specifically thought to compete with Tasmanian wool were analysed to determine the quality of wool produced in these regions. The wool quality was also examined to determine variations that may occur between seasons as well as the ways in which the quality varied between Tasmania, NSW and Victoria. The selected competing areas in NSW account for 15% of NSW wool production and in Victoria the areas thought to compete with Tasmania account for

17% of Victoria's wool production. Due to the variance in levels of production between states, quality not quantity was important to the analysis. By carrying out these comparisons it may be possible to determine if the influence of seasonal conditions on wool were similar for each state and if the wool produced within the selected areas had similar qualities to Tasmanian wool.

5.2.2 Yield

On a state basis the Tasmanian wool clip has a reputation for the highest yielding wool of all states (DPIWE, 1998). This reputation was supported by the data. The yields may be affected by the level of vegetable matter within the fleece, with higher levels of vegetable matter lowering the yields (Rogan, 1995). As Tasmania has the lowest levels of vm, then Victoria then NSW, it is thought that the vm content has the biggest influence over the yield of wools within the selected areas as the amount of vm increases, the yield of the wool will decrease.

Yield will differ due to different amounts of grease and suint content (Story and Ross, 1960). The amount of grease and suint produced by sheep will vary between breeds and bloodlines. Tasmania may have bloodlines, which produce lower levels of grease or suint hence increasing the yield.

Overall wools within NSW had lower yields, with the majority of the wool yielding between 70-75%. Victorian wools also had slightly lower yields than Tasmania. Tasmania's higher yielding wool may be due to the bloodlines of sheep, which produce wool with lower levels of grease or suint. The climate in NSW and Victoria may be less conducive to break down a portion of wool grease.

5.2.3 Style

The majority of fleeces in all WSA, seasons and micron categories in NSW and Victoria fall into either best or good topmakers, with very few fleeces being classified in the spinners categories. As style is a subjective measurement there may be geographical differences in the way in which wool classers are allocating styles. From these results 90% of wool in NSW and Victoria are either allocated best or good topmakers with very few fleeces being classed as a spinners or average/inferior topmakers whereas Tasmania has a higher allocation of wool to spinner types (6%).

It is hard to determine if there were any physical differences between styles of wool from different states as no objective measurements of style components were available at the time the data set used in the analysis was collated. In NSW and Victoria few fleece wools may classify for spinner types due to the higher levels of vegetable matter present in the wool compared to Tasmanian fleeces. Tasmanian wool may also have less dust penetration throughout the fleece due to their slightly higher yields accounting for the higher amount of fleeces than NSW and Victoria in the spinners categories.

5.2.4 Colour

Seasonal variation has the biggest influence on colour fault for all three states. The seasonal variation is highlighted by the difference in colour fault levels between the seasons, however the seasonal fluctuations, which are fairly similar for NSW and Victoria, are different for Tasmania. This is due to different weather patterns across the states with the wet and dry seasons not necessarily being the same for each state or WSA.

The levels of medium and heavy colour faults were low for each state. This was to be expected due to the fine diameter wool which generally had low scores for discolouration (Atkins *et al,* 1994). The low levels of heavy colour faults were also due to effective skirting and classing of the fleece wool, which removes urine stains and dags. From this subjective data none of the states had a significant advantage over the others with the levels of colour being similar for all states with seasonal variation having the largest influence on colour levels.

As these results for colour are assessed subjectively it can not be determined if the subjectively measured colour fault for each state is comparable. However, as the new objective colour measurements are adopted it will be possible to determine if the unscourable colour fault in Tasmania is the same level as NSW and Victoria and whether seasonal impact still has the greatest influence on colour fault or if it is essentially the breed/bloodline of the sheep, which is the largest contributor to colour fault.

N05 has significantly higher level of colour fault than other WSA within Victoria, NSW and Tasmania, this maybe due to the higher level of crossbreeds throughout N05 or the particular breed or strain of sheep within N05 being prone to discolouration.

5.2.5 Staple Strength

Staple strength is an important component in both marketing and processing of raw wool and has long been viewed as a function of the prevailing environmental conditions. A number of environmental and management factors have contributed to the difference in strength between states.

Tasmania has a reputation for greater general soundness in relation to wool from most other areas of Australia. Research by Butler (1994) shows Tasmania to have a higher average staple strength than the rest of Australia. However, when specific fine wool producing areas in NSW and Victoria are isolated to compare with Tasmania, it was found that Tasmania had a higher incidence of tender wool compared to most areas.

The reason for the higher incidence of strength faults is thought to be due to a number of different management issues. Increased uptake of objective measurement should increase the awareness of strength problems amongst growers hence gradually reducing strength faults.

There appears to be more climatic affect in Victoria and NSW than Tasmania. The levels of staple strength faults have fluctuated throughout the six seasons within Victoria and NSW. However, although Tasmania has high levels of faults the levels appear to be slowly decreasing over the seasons. This may be a coincidence or may suggest that the strength problem in Tasmania is largely attributed to by management procedures. More accurate results of this could be determined when there is a greater availability of objective measurements for strength. Overall there does not appear to be a noticeably different amount of staple strength faults occurring in any one state. Staple strength is variable between seasons and WSA. Victoria has a higher incidence of strength faults than NSW.

The seasonal variation is thought to be due to change in climatic conditions therefore influencing pasture growth and availability. Since the biggest influence on strength is management procedures then the majority of change between WSA can be related to different management practices.

Victoria and Tasmania have a higher proportion of strength faults than NSW, they also have a higher proportion of autumn lambing (*pers. com.* M.Best). This places the addition of the pregnancy/lactating stress at the same time as the winter feed deficit therefore increasing the likelihood of a break in the fleece and increasing the occurrence of strength faults (Bigham *et al.*, 1983).

Other management factors that may contribute to the different levels of staple strength in each state are different breeds/bloodlines although there is little evidence in previous research that strength varies much between strains/bloodlines. Age may also have an effect, the older the ewe the greater incidence of strength fault. So if a flock has a higher proportion of older animals it may lead to an increase in tenderness throughout the flock. Ewes are more prone to tender fleeces than wethers due to increased stress from pregnancy/lactation therefore if flocks have a higher proportion of ewes to wethers it may increase the proportion of tenderness over the flock.

The incidence of fleece tenderness may also be increased by winter feeding of forage crops, submaintenance winter feeding and increased stocking levels (Bigham *et al.,* 1983). Time of shearing also has a major effect on staple strength. To reduce the incidence of tenderness within the fleece shearing should occur when the break in wool is at either the tip or base of the staple.

5.2.6 Vegetable Matter

The consequence of vm on processing varies enormously dependent on the type and quality of vm. The extent to which vm causes a problem in the wool is determined by the vmb levels. NSW and Victoria had a greater proportion of wool with higher levels of vmb. All the fleece wool throughout the three states had relatively low levels of vm, which is typical of wool grown in high rainfall, temperate areas (Rogan, 1995).

There were differences in vm content between both WSA and seasons. The major contributor to variation in the extent and type of vm contamination in wool is the composition and growth characteristics of pasture grazed by the sheep (Atkinson, 1989; Lunney, 1981) and the preparation of the fleece (Charlton, 1985). Hence the low levels of vm in Tasmanian WSA are attributed to the composition and growth characteristics of pasture grazed by the sheep, as there would be little difference in fleece preparation between the states (*pers. com.* R.Wallace).

The type of vm that is present within the fleece wool is also important as type of vm has the biggest influence on processing. NSW, in contrast to Tasmania and Victoria had a higher proportion of burr fault present throughout the clips. Burr can be more difficult to remove in carding and therefore tend to be transferred through to gilling to the combing stage where they are largely removed, however removal at this stage results in an increased fibre losses (Bow *et al.,* 1989).

5.3 The Influence of Wool Characteristics on Raw Wool Price

5.3.1 Introduction

Prices received at auction are extremely volatile. However it has been demonstrated that 92% of the variation in clean price of Merino fleece wool sold at auction is determined by fibre diameter, staple strength, staple length, vegetable matter and colour of the wool (IWS, 1995).

5.3.2 Clean Price

Despite the fact that the clean price was always highest for the fine wool there was no significant difference shown between prices for fine, medium and strong wool due to the volatility of wool prices. Over the six seasons analysed the prices ranged from approximately 600 c/kg to over 1200 c/kgs. It was expected that the fine wool would receive a higher price than the medium wool, which would be higher than the strong wool, due to the influence of fibre diameter has clean price however, there was no significant effect.

5.3.3 Fibre Diameter

Fibre diameter has consistently been the most important characteristic that determines clean price of raw wool. It accounts for at least 80% of the variation in clean price (Andrews *et. al*, 1997). The reason for this is that fibre diameter, along with yield, are the most important wool characteristics which influence processing (Teasdale, 1988). There was no significant difference in price between the three states for variation in fibre diameter within the fine wool. This is due to the high variation between prices received for each season.

Fine wool incurred heavier penalties than medium or strong wool as fibre diameter increased. As fine wool receives higher prices than medium or strong it is expected that the penalties would be higher.

Within the medium wool, Tasmania (8.8 c/kg) received consistently lower discounts than NSW and Victoria (10.2 c/kg). This difference was significant in three seasons (1991/92, 1992/93 and 1994/95). This may indicate that buyers are less concerned with increased fibre diameter in Tasmanian wool and are less likely to penalise the wool. This does not occur in NSW and Victoria. Lower discounts in Tasmania may be influenced by the good reputation Tasmanian wool has for producing quality products amongst the buyers and processors.

Another contributing factor maybe the time of sale and the demand at this time, as the majority of Tasmania's wool is sold at wool sales in Launceston. If demand is high then discounts may be lower, as buyers are concerned more with sourcing the product.

Amongst the strong wool there was significant differences between penalties for fibre diameter increase between Tasmania, Victoria and NSW. However there was no clear pattern for the discounts received. This highlights the volatility of price discounts received at different sales throughout Australia.

5.3.4 Yield

There were no significant price discounts that occurred for a decrease in yield between NSW, Tasmania and Victoria. This was expected, as yield does not account for large variations in clean wool price (IWS 1995) even though it is extremely important to determine the amount of useable fibre.

When data from the three states was pooled an increase in clean price occurred as yield of wool increased. This was slightly higher for fine wool. This was thought to be due to higher prices received for fine wool, however the increases received were small, less than 0.5% (per unit increase in yield) rise in clean price.

5.3.5 Style

Style effects between states did not have a significant affect on price discounts due to the low amount of data within each style category for each states. However when the three states were combined a larger data base was obtained and significant price effects for style were observed. As best topmakers had the largest number of fleeces it was made the base style and discounts and premiums were calculated around this category.

As style is a subjectively assessed characteristic and there is no consistency between assessments, it is difficult to have constant and significant price penalties or premiums for any one style. However, all spinners styles received a premium price and this was higher in the fine wool than medium and strong fleeces. Penalties were more pronounced within the fine wool as compared to the medium and strong. Short and very short fleeces received the largest discounts. As the style grading takes into account the average fibre diameter and greasy staple length, these price discounts and premiums are to be expected.

Wool style illustrates the interaction between the fleece grown and the condition under which it was grown. Wool style has largely been divorced from the processing aspects of fleeces (Winston, 1988) as style is largely a reflection of the environment (Ford and Jackson, 1994) and is of little importance to processors. The price discounts and premiums, which can be seen for style differences, are largely influenced by other wool characteristics such as fibre diameter, vm content, colour and length.

5.3.6 Colour

Light and medium colour has only a small influence on price (IWS, 1997/98). Colour was subjectively measured and research has demonstrated that the subjective assessment of clean colour from the appraisal of greasy wool can be unreliable. It is estimated that Australian wool is discounted about 0.4% of its value because of appraised unscourable colour. This represents up to $20 million per year in discounts on current wool prices (Teasdale 1988). The introduction of an objective colour measurement and the uptake of this measurement by farmers will assist in ensuring only wools with unscourable colour are discounted.

There was no pattern of significant difference between the three states for either light or medium colour. Tasmanian discounts became greater, in most cases, as the wool became coarser, however in NSW and Victoria the discounts became less as the wools became coarser. This may be due to more competition within Australia for fine wool therefore the discounts for the wool will not be as high, as the competition pushes prices up.

The colour penalties in general were not as high in Tasmania as in NSW and Victoria, although this difference was not significant. Thus it appears from this data, that buyers were less likely to highly discount Tasmanian wool for colour. This may be due to the good reputation of Tasmanian wool hence increasing demand.

The results for heavy colour fault were disjointed due to the low occurrence of heavy colour amongst the three states fleece wool. Therefore no conclusion can be drawn about price penalties and heavy colour fault.

5.3.7 Staple Strength

Generally as staple strength increases, so too does the price received. Tender wool receives a price discount relative to sound wool because it processes less efficiently. Traditionally the wool buyer, processors and classers have relied on the hand held 'flick test' to assess the strength of wool. The results for the three states are based on this subjective measurement. Previous research (Bell, 1987) has shown that it is difficult to break a staple in excess of 30 N/ktex and that wool classers differed in both the force they applied to the staple and the thickness of the staple selected.

Differences did occur between the price discounts received for each state however there were no significant price trends. However, as with colour discounts Tasmania generally had the lowest discounts for faults within fine and medium wool. This again may indicate that buyers compete to purchase Tasmanian wool because of its superior reputation and demand for the wool may push prices slightly higher.

The results indicate that there is no set discount for strength faults and that they vary noticeably between seasons with no obvious trends.

5.3.8 Vegetable Matter

Vegetable matter contamination is the major price determinant of the relative clean price of wool after fibre diameter, as it increases wastage during carding and combing and failure to remove it during processing results in rejection or costly mending of fabrics (Whiteley, 1990). Price penalties differ according to the level of vm present in the fleece.

Due to the low levels of vm present in fleece wool throughout the states it was not possible to obtain individual price penalties of vm for each state. However, the results were pooled and allowed the determination of price penalties between vm types. There was however no significant difference between price penalties and vm type. This is probably due to the low amounts of vm present. The results did however indicate that the price penalties for vm are relatively low when vm is present at low levels. Therefore lowering levels of vm in fleeces throughout these WSA is not of high economic importance to farmers in these areas.

5.4 Cost of wool faults to Tasmania, New South Wales and Victoria

The cost of both colour and strength faults for every kilogram of wool produced was determined for each state. This allows a cost comparison between the states and determines which characteristics have the biggest influence on price return for the wool.

This was not determined for other wool characteristics due to the low amount of data.

Colour costs the state notably less than strength, with Tasmanian costs falling between Victoria and NSW in the medium and fine wools and being the lowest in strong. Hence colour is of little economic importance to Tasmania.

From these analyses it can be determined that staple strength has the largest economic influence in all states and this influence is greatest within medium wool. Tasmania, on average, is penalised 1.7c/kg (for each N/ktex decrease in strength) more than Victoria and 4.2c/kg NSW. As 40% of Tasmanian wool falls in the medium category, this is the area of the highest economic importance for producers to improve.

5.5 CONCLUSION

The quality of Tasmanian wool is similar to selected fine wool areas within NSW and Victoria. There was variation between seasons and states, however in most cases seasonal variation was greater than variation between WSA. This was due to the boundaries of WSA not representing geographical or climatic changes relating to wool production.

It was determined that Tasmania's wool quality varied considerably between seasons and across the state. Tasmanian wool had high levels of staple strength faults throughout the state that seemed to be influenced more by management than season. Colour fault levels were low except in the northern part of the state where the annual rainfall is high and there is a higher proportion of crossbred sheep, both these factors contributing to higher levels of colour in the fleece wool. Vegetable matter fault was at very low levels across the state and rarely reached above the 1.1% level in the fleece wool. The only significant type of vegetable matter present was seed/shive, burrs and hardheads occurred at insignificant levels.

There were high levels of variation between seasons in all states, and Tasmania did not show less variation compared to mainland competitors. However upon comparing the levels and variation of the various faults across the three states, Tasmania had the lowest levels of vegetable matter fault. Colour levels within the fleeces were influenced by the climatic conditions of the season and followed a seasonal pattern across the six seasons (1991/92 to 1996/97) within all states. Tasmania had the lowest levels of colour fault excluding the northern area of the state. Staple strength is the area of wool quality where Tasmania is comparatively weak in comparison to competing regions in NSW and Victoria.

However as strength was identified as mainly being influenced by management rather than seasonal conditions the key to improving strength in Tasmania is to determine the combination of management practices that are producing sound wool. The increased uptake of objective measurements for strength and position of break will multiply awareness of this problem amongst producers. Identifying the growers who are producing sound wool and determining the methods with which they are reducing the occurrence of faults and variation within their clip may do this. The different management practices may also be looked at between the states and could assist in increasing the soundness of Tasmanian wool.

Tasmania has the advantage over NSW and Victoria in that it has low levels of both colour and vegetable matter, two characteristics that are harder to manipulate through management.

Once the key management issues have been identified to reduce the amount of strength faults within Tasmanian wool the knowledge must be transferred to all wool producers to increase the value of the state's wool. Therefore, allowing Tasmania to produce sound wool and uphold and maintain it's reputation for producing high quality Merino wool.

Appendix One:

Working Example of Section 3.4

Fine wool production for the 1996/97 season in Tasmania

1. Total production = 8,104,880 kg
2. W1 fault production = 177,320 kg
3. % W1 fault = 177,320/8,104,880 x 100

   = 2.19%

4. Discount Coefficient (calculated in Section 3.3) = 57.09c/kg

5. Total cost to all fine wool produced in Tas in 1996/97:

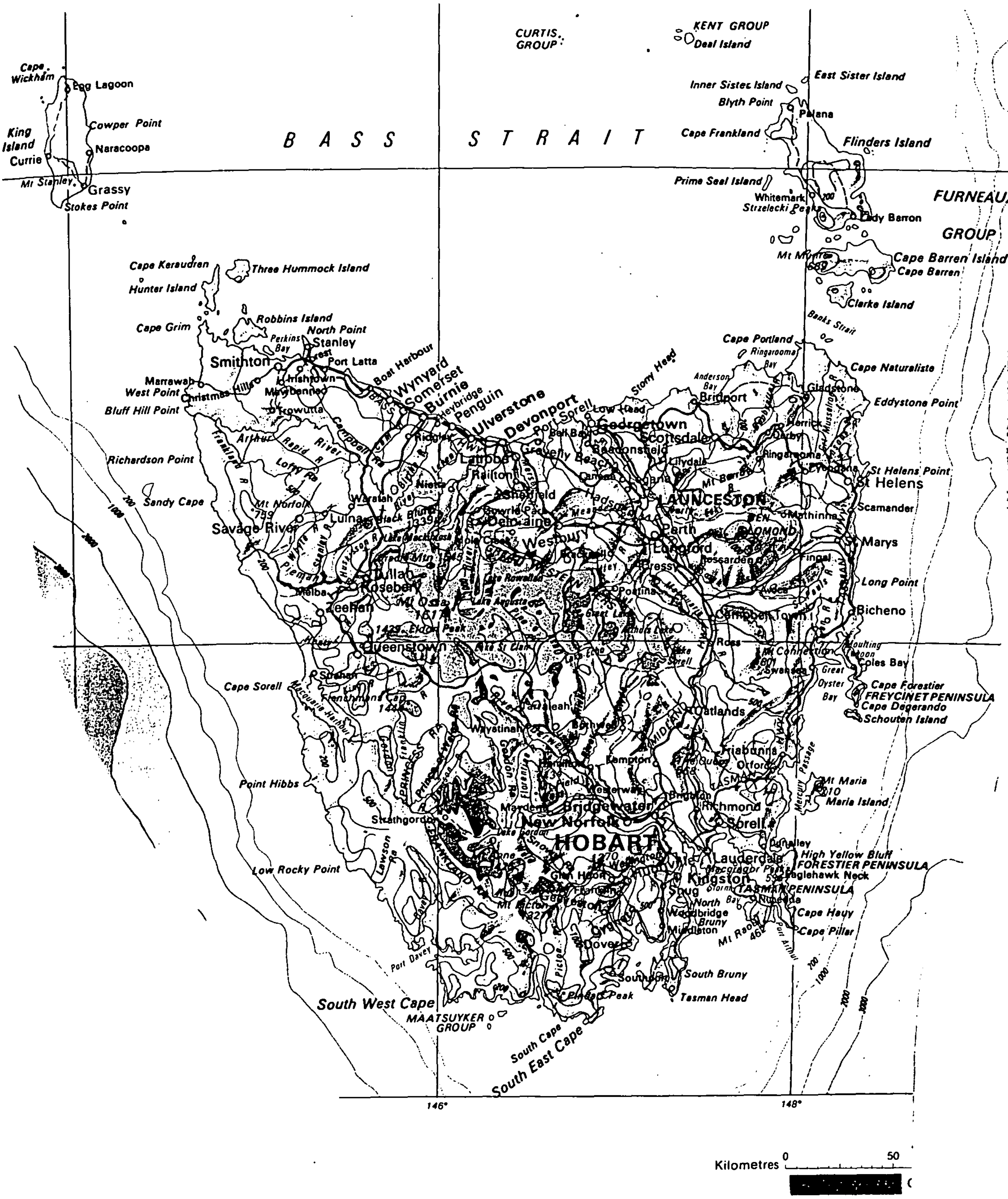
   = Discount Coefficient x % W1 fault

   = 57.09 x 2.19%

   = 1.25 c for every kg of fine wool produced in Tas in 1996/97

Appendix Two:

Map of Tasmania (Macquarie World Atlas, 1994)



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